Nordic Circular Economy Playbook

Circular business models for the manufacturing industry

Nordic Innovation

This playbook will help you:

Define general and clear business benefits from circular adoption

Develop the right operating models to realize full benefit

Establish the means to drive change

Disclaimer: This playbook is part of the program Nordic Sustainable Business Transformation by Nordic Innovation. Accenture is responsible for all its content.

This playbook is tailored to companies in the Nordic manufacturing industry, giving examples for the following five sub-sectors:

(1) machinery & equipment, (2) maritime, (3) energy, (4) transportation, (5) construction

This playbook can be leveraged by companies that want to

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

The playbook calls for action by

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

Playbook content

Guidance for companies on how to achieve a step-change towards the circular economy and successfully make the transition

Tools

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 1 - 5
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 the 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

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

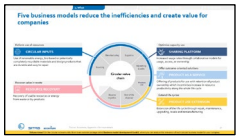
1. Why the circular economy?

Content

Burning platform for the circular economy

- Inefficiencies of the linear value chain
- Drivers of the circular economy
- Leading examples

2. What opportunities exist?



Circular opportunities for manufacturing industry

- Current state analysis
- Circular business models
- Value benefits

3. Which capabilities are required?

9 circular capabilities

- Detailed description
- Required know-how
- Recommended approach
- Leading practices

4. Which technologies can support?

19 technologies enabling circular business models

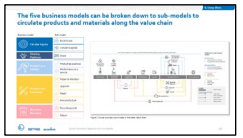
- Detailed descriptions
- Circular relevance
- Assessment parameters
- Risk assessment

5. How to design the transformation journey?

Circular transformation journey and roadmap

- Envision and plan
- Deliver and adapt
- Barriers incl. culture, ecosystem collaboration, finance

6. Industry deep dives



Current state analysis and circular opportunities for

- Machinery & Equipment
- Maritime
- Energy
- Transportation
- Construction

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

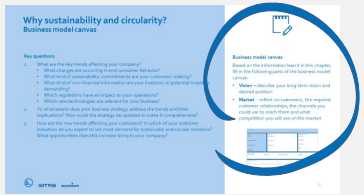
While reading the playbook, use the business model canvas to start developing your circular business opportunities

What is a business model canvas?

The business model canvas is a tool that helps you to crystallize your circular business idea by reflecting on its key building blocks, including your value proposition, infrastructure, customers and financing.

How to use it?

Chapter 1 – 5 supports you with filling in the canvas. We also recommend using the tool and questions with your team to support discussion and ideation.



Vision statement

Market

Customers:

Customer relationships:

Customer Channels:

Competitors:

Offering

Products/services:

Value proposition:

Outlook/pipeline:

Operating model

Key partners:

Key capabilities:

Key resources:

Digital:

Financial aspects

Revenue streams:

Cost structure:

Risks (facing /mitigating):

Intangibles:

Enabling companies

"The Nordic prime ministers have a vision of the Nordics being the most integrated and sustainable region by 2030. One of the action areas is the adoption of circular business models by Nordic companies. The playbook provides companies with the tools to do just that. I hope it will be widely used by companies in the Nordics to enhance their competitiveness and value creation by going from a linear value chain to a circular ecosystem. It also builds on the Nordic common strongholds like access to raw materials, a digital and highly educated population, and the ability to adapt. In this lies great potential for being the most competitive and circular companies in the world. After all, if we don't do it, someone else will."

Marthe Haugland, Senior Innovation Advisor, Nordic Innovation

"We have an urgency to change our economy to respond to climate change, decreasing biodiversity, the dwindling availability of resources and waste-related problems. A big change in industrial culture, mindset, capabilities and behavior is needed; Shifting the focus from production to the customer and maximizing the value of the existing products with data and new technologies, while decoupling value creation from resource consumption. Not only is the circular approach financially very viable, it is realistically the only way to be able to operate in the future. This Playbook is a manual for change. It gives you tools to build up your sustainable business models and design the transformation journey from industrial value-chains to cross sectoral ecosystems. By taking steps towards circular business you gain competitive advantage, attract investors and create sense of purpose."

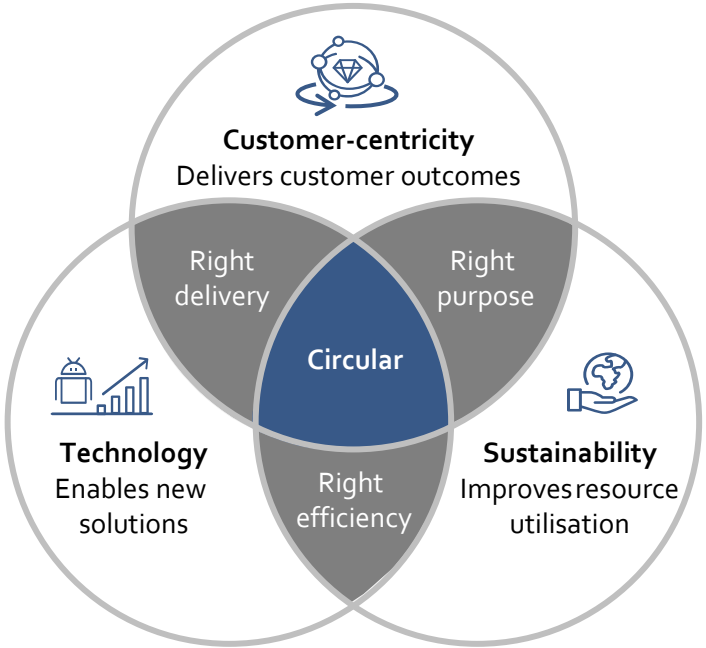
Jyri Arponen, Senior Lead, Business Development, Circular and Data Economy, The Finnish Innovation Fund Sitra

"Achieving a circular economy requires a fundamental shift in how companies operate and generate revenues. This playbook and tools, provide a great starting point for companies to assess, test and innovate together with peers and ecosystem partners to drive lasting change. I'm thrilled to see how our network of companies and the number of innovations keep expanding every year."

Anna Belvén Töndevold, Nordic Sustainability Strategy Lead, Accenture Strategy

Executive summary

Complementary drivers accelerate the shift towards enhanced sustainability and the circular economy in the Nordics



Customer centricity

Better customer values can be delivered through offering outcomes instead of selling product. Profit is generated by delivering solutions that fit specific customer needs, minimizing inefficiencies and improving consumer experience

Sustainability

Our overuse of natural resources drives increased regulatory pressure, investments are shifting towards responsible businesses and businesses raise supplier requirements

Technology

Technology enables new innovative efficiencies and drives new communication channels, processes and ways of working, and ultimately enables better use of resources and economic growth.

Source: Accenture, Appendix 2 for more details

The circular economy is about turning inefficiencies in linear value chains into business value

Inefficiencies in linear value chains

1. UNSUSTAINABLE MATERIALS

Material and energy that cannot be continually regenerated

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

2. UNDERUTILISED CAPACITIES

Underutilised or unused products and assets

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

3. 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

4. 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

Putting the customer at the centre enables companies to focus on the value adding activities

5. UNEXPLOITED CUSTOMER ENGAGEMENTS

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

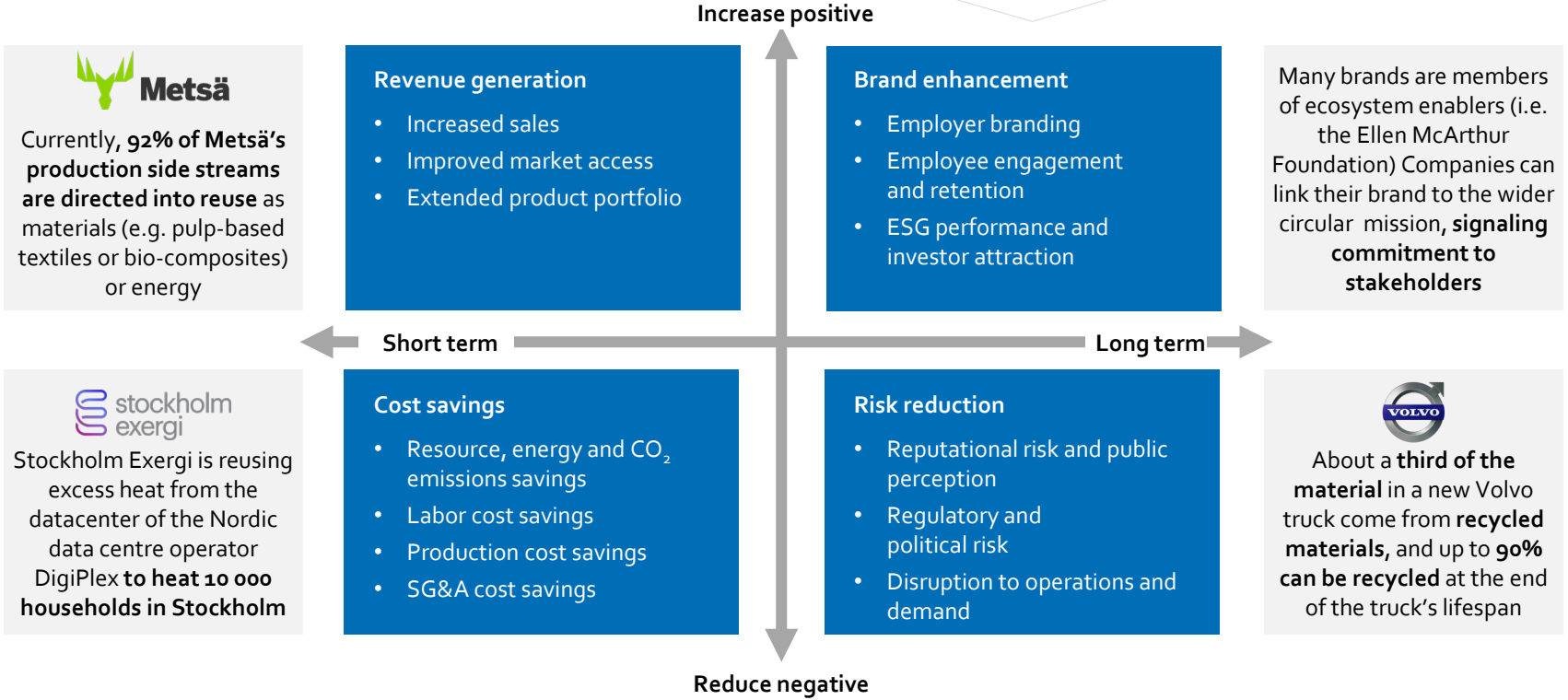
– for example, missing opportunities to engage customers throughout the product life-cycle to offer additional services and add-on sales

Source: Accenture, Appendix 2 for more details

By adopting sustainable and circular business models, companies can create value in four dimensions

Brand enhancement and risk reduction are typically achieved in the long-term, therefore companies need to take a longer time horizon into account when making investments in circular business models

Sustainable value creation framework



Metsä

Currently, **92% of Metsä's production side streams are directed into reuse** as materials (e.g. pulp-based textiles or bio-composites) or energy

Many brands are members of ecosystem enablers (i.e. the Ellen McArthur Foundation) Companies can link their brand to the wider circular mission, **signaling commitment to stakeholders**

stockholm exergi

Stockholm Exergi is reusing excess heat from the datacenter of the Nordic data centre operator DigiPlex **to heat 10 000 households in Stockholm**

VOLVO

About a **third of the material** in a new Volvo truck come from **recycled materials,** and up to **90% can be recycled** at the end of the truck's lifespan

Source: Company websites, Accenture – Appendix 2 for more details

Five business models reduce the inefficiencies and create value for companies

Reform use of resources

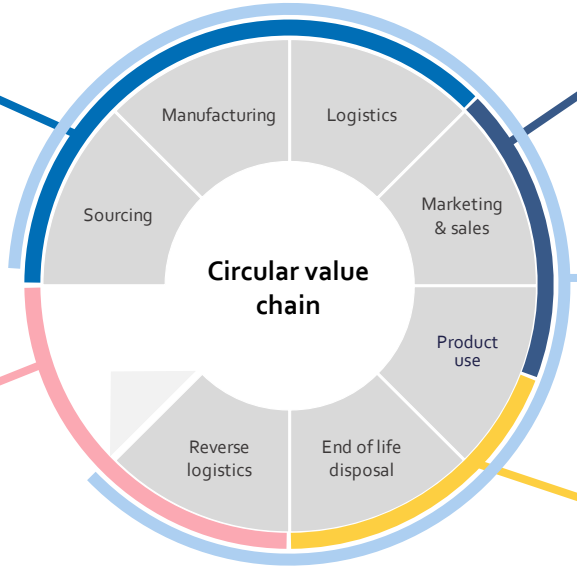
CIRCULAR INPUTS

Use of renewable energy, bio-based or potentially completely recyclable materials and design products that are durable and easy to repair

Recover value in waste

RESOURCE RECOVERY

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 lifecycle

Extend lifecycles

PRODUCT USE EXTENSION

Extension of the lifecycle 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 analyze the relevance of each circular business model for your company.

Current adoption level of circular models in the Nordic manufacturing industry is highest within circular inputs and product use extension

Business model	*Sub-model*	*Adoption level*	*Comment*
CIRCULAR INPUTS	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, but being explored
	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, as many of the products are fixed installations or have a high degree of customization
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. Some companies are finding it challenging to find an investment model and achieve a win-win situation for both customers and the company
	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 USE 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
RESOURCE RECOVERY	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, the products are not built for circularity and it is difficult to separate materials and even know the product composition
	Return	Not applied at all — Widely applied	Most companies recycle some of their manufacturing waste

Source: Analysis based on output from Nordic Circular Industries workshops. More detailed information on the output 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.

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

Linear value 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 lifecycle management services
- Improved understanding of customer and product requirements can be achieved through continuous interactions and data analytics

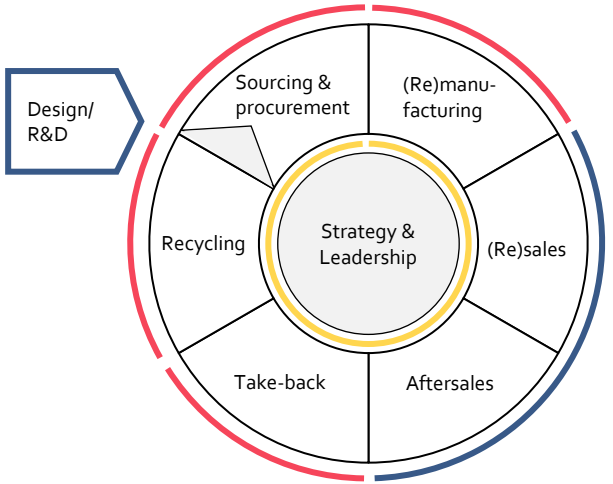
B) Resource handling

- 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

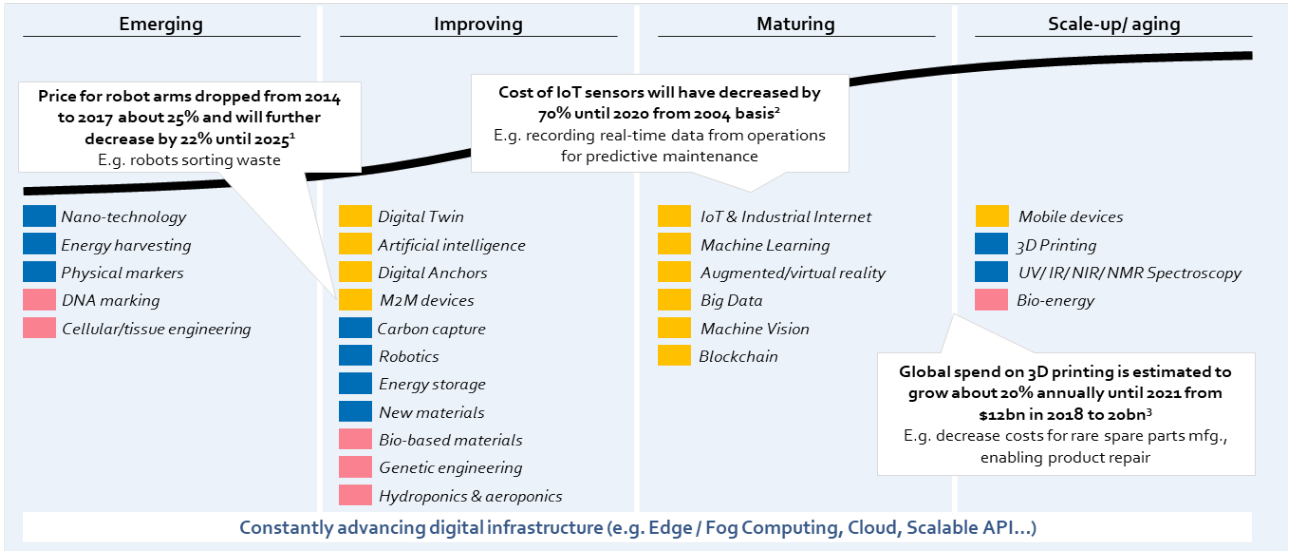
- Use of IT and digital technologies is not enough, companies further need the ability to collect and derive valuable insights from data
- Collaboration is needed to optimise customer outcomes and value creation with partners aligned to end-to-end value creation

Circular value chain



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

Digital, physical and biological technologies are developing at rapid pace, enabling circularity



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

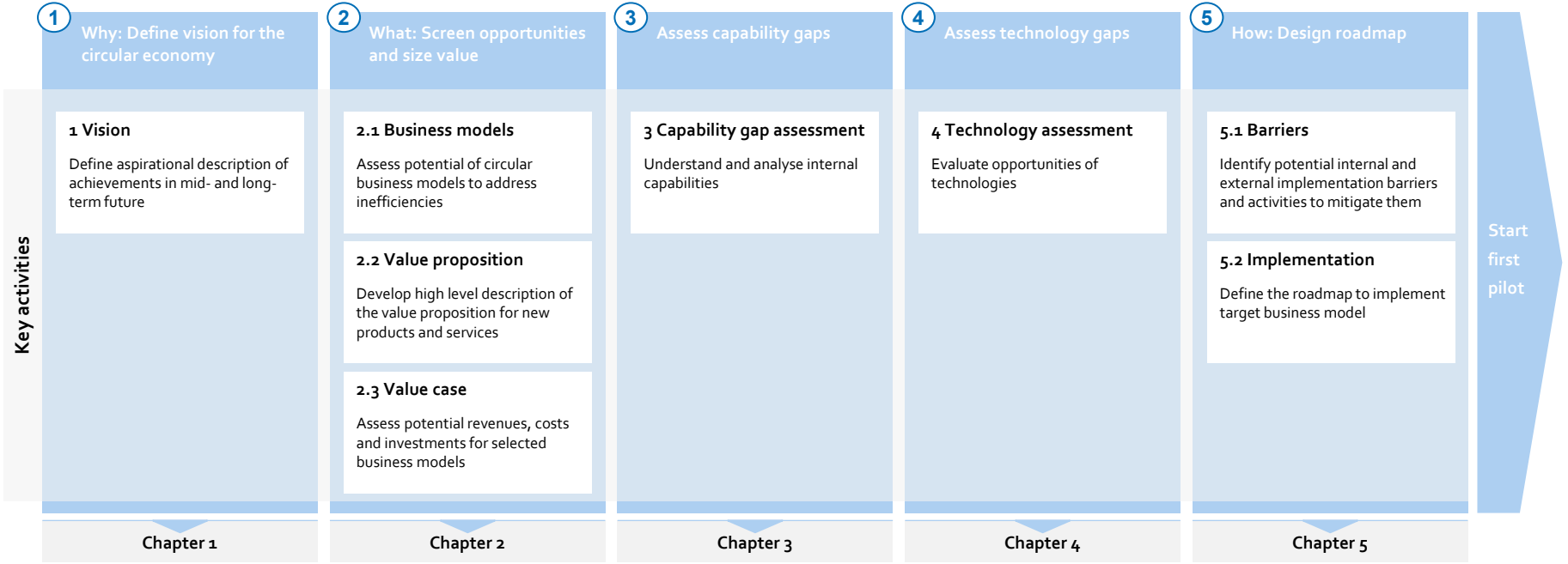
Type of technology: Digital | Physical | Biological

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

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.

Five steps are critical to envision and plan a successful transformation

Key element no. 1: "envision and plan"



1 Why is the circular economy relevant?

Rationale for Nordic manufacturing companies to engage in the circular economy

CHAPTER SUMMARY

Why is the circular economy relevant?

This chapter will help you to:

- Understand why the 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

- The circular economy is relevant as it offers companies the opportunity to turn inefficiencies in linear value chains into business value
- These inefficiencies go 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 Nordic companies have already started to successfully address inefficiencies through circular principles and are unlocking value from waste

The circular economy is about turning inefficiencies in linear value chains into business value

Inefficiencies in linear value chains

1. UNSUSTAINABLE MATERIALS

Material and energy that cannot be continually regenerated

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

2. UNDERUTILISED CAPACITIES

Underutilised or unused products and assets

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

3. 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

4. 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

Putting the customer at the centre enables companies to focus on the value adding activities

5. UNEXPLOITED CUSTOMER ENGAGEMENTS

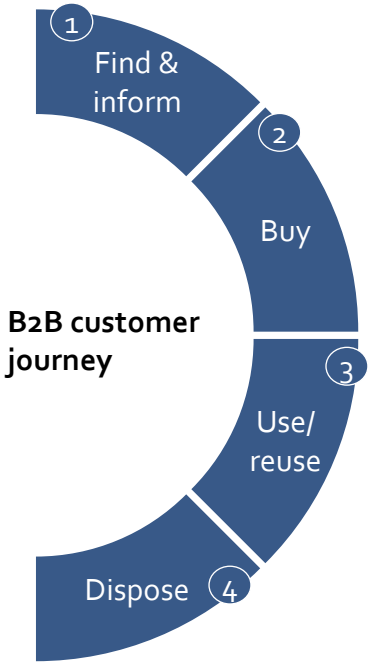
Sales organisation focus on selling functionality of products rather than addressing the customer problem

– 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

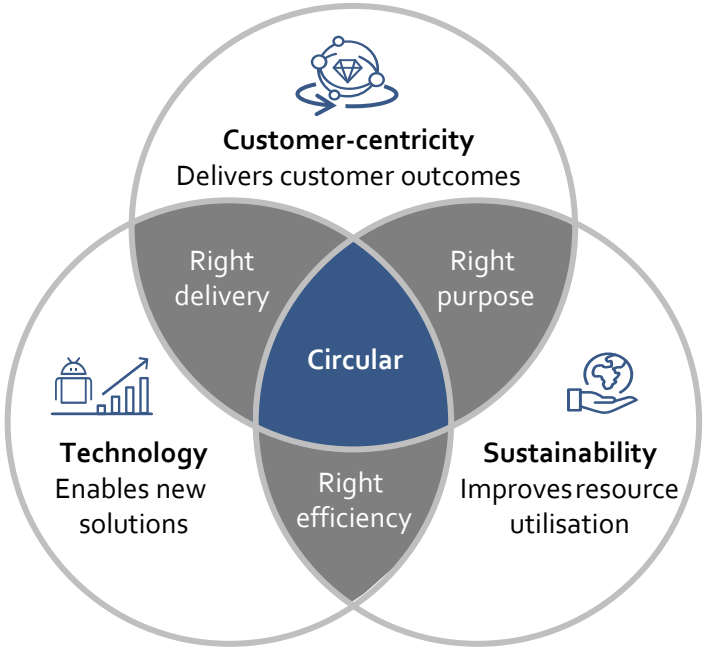
Circular business models can further strengthen customer relationships by addressing frequent customer pain points

Customer pain points



Customer expectation	Potential pain points along the customer journey
Convenient and informed purchasing options	• Insufficient information available online • Product or service benefits unclear or unquantified • Lifecycle costs and benefits hard to quantify or non-proven
Customized solutions	• Challenging to find exactly right product to customer need • Lack of options for customization • High initial purchase price • Lack of financing models
Comprehensive services	• High efforts for maintenance • Insufficient know-how for optimized use • Unavailability of spare parts or maintenance • Repair or upgrade unavailable
Sense of responsibility	• Costly disposal • Few locations or services to get rid of product • Lack of information on disposal channels

Complementary drivers accelerate the shift towards enhanced sustainability and the circular economy in the Nordics



Customer centricity

Better customer values can be delivered through offering outcomes instead of selling product. Profit is generated by delivering solutions that fit specific customer needs, minimizing inefficiencies and improving consumer experience

Sustainability

Our overuse of natural resources drives increased regulatory pressure, investments are shifting towards responsible businesses and businesses raise supplier requirements

Technology

Technology enables new innovative efficiencies and drives new communication channels, processes and ways of working, and ultimately enables better use of resources and economic growth.

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

From Kongsberg selling engines…

… to offering outcomes

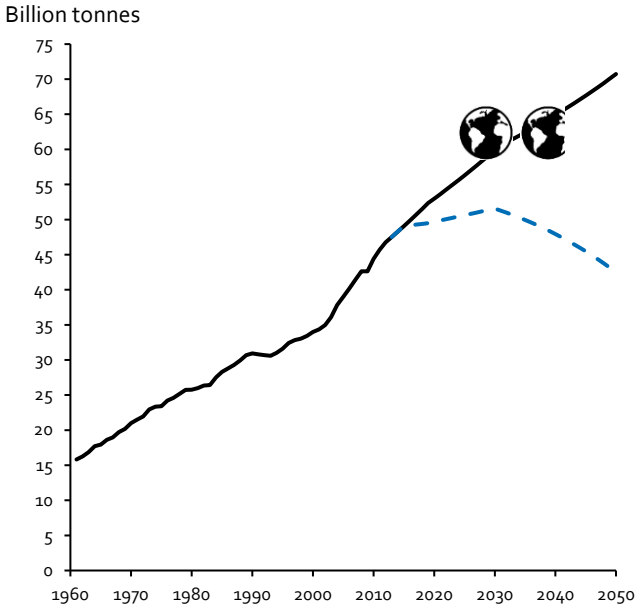
Profit is generated by **delivering solutions** that fit specific customer needs, **minimising inefficiencies** and **increasing consumer experience**

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

Source: 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

The European Green Deal, launched by the European Commission, is a roadmap for making EU the first climate-neutral continent by 2050[2]

BlackRock CEO Larry Fink asks companies to make positive contribution to society[3]

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[4]

Source: 1: Accenture, Appendix 2 for more details, 2: European Commission, 3: CNN, 4: CDP

Regulations are being put into place to drive transition – The European Green Deal playing a key role locally

European Green Deal

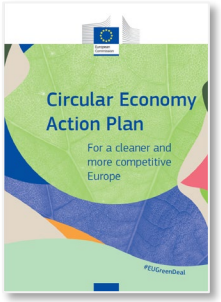
- Roadmap for making **EU the first climate-neutral continent by 2050** through actions that
  - Boost the efficient use of resources by moving to a clean, circular economy
  - Restore biodiversity and cut pollution
- Leverages all policy levers, including regulation and standardization, investment and innovation, national reforms, dialogue with social partners and international cooperation to boost the transition to a more sustainable future

The new Circular Economy Action Plan supports companies to tap into new sustainable business opportunities

Circular Economy Action Plan

Set of initiatives to establish a coherent product policy framework:

- Make sustainable products, services and business models the norm in the EU
- Transform consumption patterns so that no waste is produced in the first place
- Measures to reduce waste and ensure that there is a functioning market for high quality secondary raw materials



Sustainable product policy framework

Designing sustainable products

- A common set of design principles for all products
- Includes principles as extending product lifecycles, increasing energy and resource efficiency, incentivizing product-as-a-service, promoting digitalization of product information etc.

Empowering consumers

- Revision of the EU consumer law to ensure that consumers receive trustworthy and relevant information on products at the point of sale, including information on their lifespan and on the availability of repair services, spare parts and repair manuals

Circularity in production processes

- Facilitating industrial symbiosis by developing an industry-led reporting and certification system and enabling the implementation of industrial symbiosis
- Promoting the use of digital technologies for tracking, tracing and mapping of resources

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

Digital Physical Biological

Technologies

Emerging	Improving	Maturing	Scale-up/aging
Nano-technology	*Digital Twin*	*IoT & Industrial Internet*	*Mobile devices*
Energy harvesting	*Artificial intelligence*	*Machine Learning*	*3D Printing*
Physical markers	*Digital Anchors*	*Augmented/virtual reality*	*UV/ IR/ NIR/ NMR Spectroscopy*
DNA marking	*M2M devices*	*Big Data*	*Bio-energy*
Cellular/tissue engineering	*Carbon capture*	*Machine Vision*	
	Robotics	*Blockchain*	
	Energy storage		
	New materials		
	Bio-based materials		
	Genetic engineering		
	Hydroponics & aeroponics		

Price for robot arms dropped from 2014 to 2017 about 25% and will further decrease by 22% until 2025[1]
E.g. robots sorting waste

Cost of IoT sensors will have decreased by 70% by 2020 from 2004 basis[2]
E.g. recording real-time data from operations for predictive maintenance

Global spend on 3D printing is estimated to grow about 20% annually until 2021 from $12bn in 2018 to 20bn[3]
E.g. decrease costs for rare spare parts, enabling product repair

Constantly advancing digital infrastructure (e.g. Edge/Fog Computing, Cloud, Scalable API…)

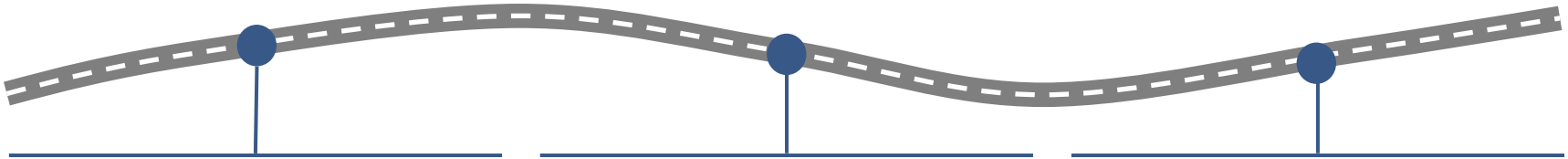
Source: 1: IEEE Engineering360; 2: Bank of America, Merrill Lynch; 3: International Data Corporation (IDC), Accenture – Appendix 2 for more details

Leading companies from the 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	eRent offers a **platform for digital sharing and tracking** of machines, devices and other goods
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	Netlet collects surplus material from construction sites and sell it discounted through platform and stores. In that way Netlet works as an enabler for construction companies, contributing to reducing waste from the construction industry 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	Metso Outotec offers **a cost per ton payment plan** where the customers receive one invoice based on actual production tonnage

Source: Company websites

Digital disruptors can take over customer relationships by leveraging the customer data they have available



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: Company websites

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

Husqvarna allows customers to share battery driven garden appliances through their Battery Box solution

- The appliances can be accessed via mobile technology
- Customers avoid the hassle of owning the equipment, including storage and maintenance
- Reduces the amount of idle garden appliances

Kongsberg offers a "Power by the hour" service agreement where the customer pays a fixed charge per hour of operation

- Remote monitoring of equipment using on-board sensors
- Customers do not have to focus on planning maintenance and monitoring the performance
- Incentivizes Kongsberg to prolong the lifetime of the equipment and capacity utilization

Wärtsilä Voyage offers full visibility of on-board operations of a vessel with an analytics solution

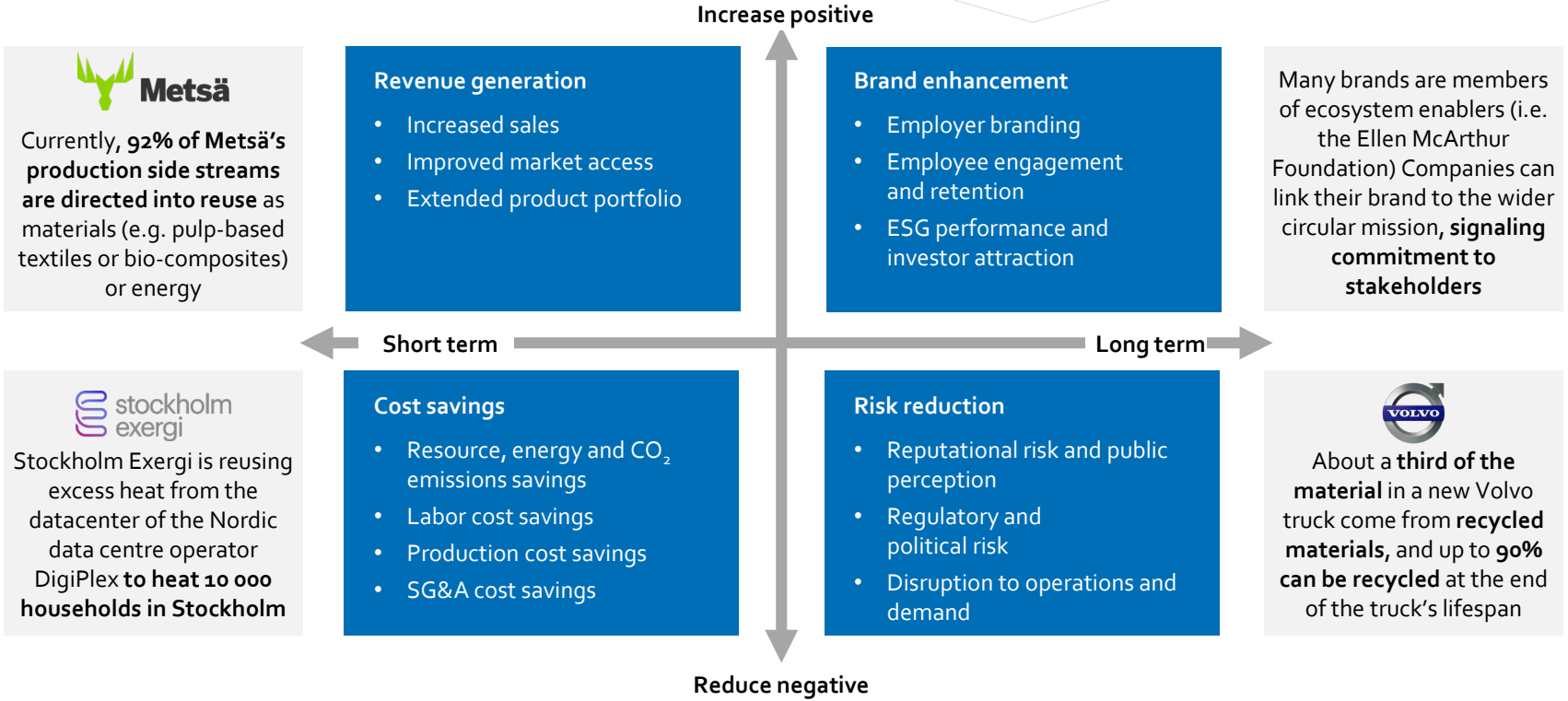
- Advanced algorithms decompose and model data
- Mobile app was jointly developed with customers
- Fuel savings are derived from optimisation and breakdown is reduced

Source: Company websites

By adopting sustainable and circular business models, companies can create value in four dimensions

Brand enhancement and risk reduction are typically achieved in the long-term, therefore companies need to take a longer time horizon into account when making investments in circular business models

Sustainable value creation framework



Metsä

Currently, **92% of Metsä's production side streams are directed into reuse** as materials (e.g. pulp-based textiles or bio-composites) or energy

Many brands are members of ecosystem enablers (i.e. the Ellen McArthur Foundation) Companies can link their brand to the wider circular mission, **signaling commitment to stakeholders**

stockholm exergi

Stockholm Exergi is reusing excess heat from the datacenter of the Nordic data centre operator DigiPlex **to heat 10 000 households in Stockholm**

VOLVO

About a **third of the material** in a new Volvo truck come from **recycled materials,** and up to **90% can be recycled** at the end of the truck's lifespan

Source: Accenture, Appendix 2 for more details , Company websites

The value of a circular initiative is driven by two levers, defined as either value migration or value addition

Two value levers

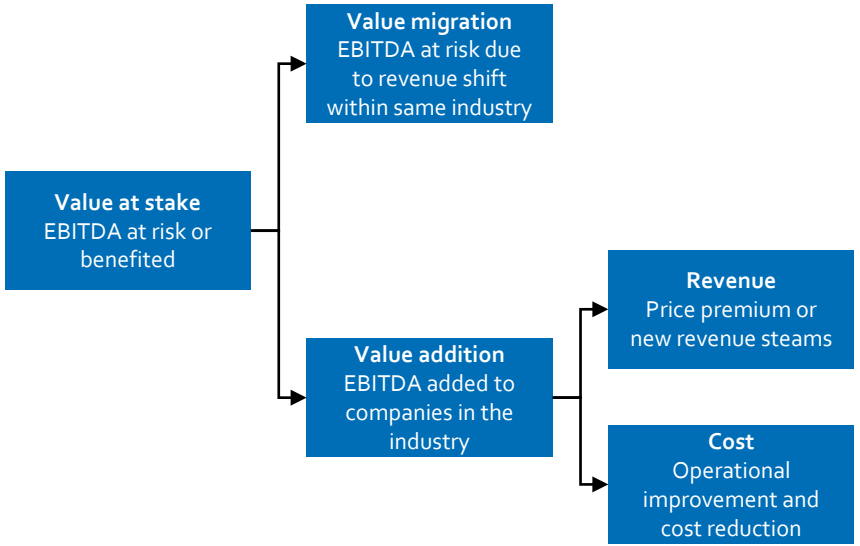
1. Value migration

- EBITDA impact of initiatives that **cause revenue to shift from one player in the industry** (who is not or less circular) **to another player in the industry** (who is more circular)
- This shift can either be driven by brand value (environmentally conscious customers who value circular products or services) or new revenues (shift in revenues from new products to higher premium products such as resale or rental)

2. Value addition

- EBITDA impact of initiatives that **increase the total revenue size or reduce costs in the industry**
- This can be driven by
    1) Revenue addition: Increases the revenue by charging higher price of a product or creating revenue streams in the industry from new products
    2) Cost reduction: Reduces the cost and waste

Value lever tree



Why sustainability and circularity?
Business model canvas

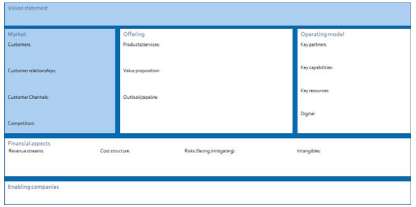
Key questions

1. What are the key trends affecting your company?
   - What changes are occurring in end consumer behavior?
   - What kind of sustainability commitments are your customers making?
   - What kind of non-financial information are your investors or potential investors demanding?
   - Which regulations have an impact on your operations?
   - Which new technologies are relevant for your business?
2. To what extent does your business strategy address the trends and their implications? How could the strategy be updated to make it comprehensive?
3. How are the new trends affecting your customers? In which of your customer industries do you expect to see most demand for sustainable and circular solutions? What opportunities does this increase bring to your company?

Business model canvas

Based on the information learnt in this chapter, fill in the following parts of the business model canvas:

- **Vision –** describe your long-term vision and desired position
- **Market** – reflect on customers, the required customer relationships, the channels you could use to reach them and what competition you will see on the market



2 What opportunities exist?

Current state analysis and circular opportunities for manufacturing industry

CHAPTER SUMMARY

What opportunities exist?

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:

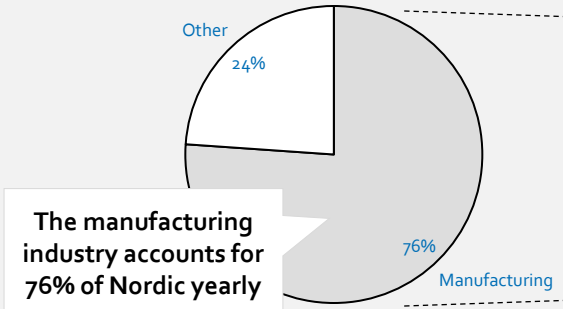
Business model development toolkit

Value case tool

- To address inefficiencies in the linear value chain and circulate products and materials, manufacturing companies should explore the five circular business models
  - Circular inputs
  - Sharing platforms
  - Product use extension
  - Resource recovery
  - Product as a service
- Compelling circular business model examples from leading Nordic 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

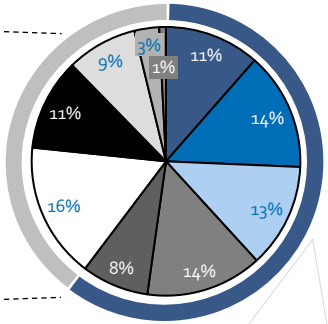
The manufacturing industry accounts for 76% of total Nordic exports

Nordic exports by industry, 2019



The manufacturing industry accounts for 76% of Nordic yearly exports

Nordic exports within the manufacturing industries, 2019



In scope

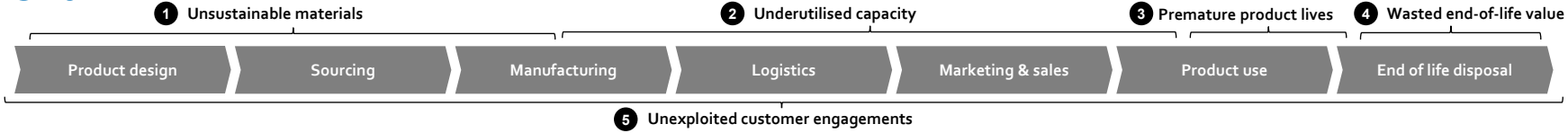
- Manufacture of machinery and equipment (11%)
- Electric and electronics industry (14%)
- Manufacture of transport equipment (13%)
- Manufacture of metal and metal products (14%)
- Forest industry (8%)
- Chemical industry (16%)
- Manufacturing of food products and beverages (11%)
- Other manufacturing (9%)
- Manufacture of textiles and clothes (3%)
- Manufacture of other non-metallic mineral products (1%)

The five sub-sectors in scope account for 60% of Nordic manufacturing exports

- The share of manufacturing exports differs between the Nordic countries, where Norway accounts for the smallest share of manufacturing (38 %). This is due to a high share of petroleum products (excluded)
- The size of these industries varies in each of the Nordic countries. The highest export revenue comes from transportation equipment in Sweden, manufacturing of food products in Norway and Iceland, chemicals industry in Denmark, and metal and metal products in Finland

Source: Nordic Statistics database, table FOTR46 for Finland, Denmark, Sweden, Iceland and Norway

Substantial inefficiencies occur in all parts of the manufacturing value chain



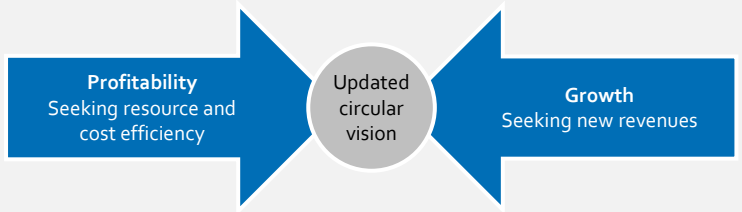
	Inefficiency	Inefficiency level	Description of quantitative results	Comments on the current state
1	Direct materials	Medium	For 39% of companies the spend on recyclable/renewable materials is 50% or more of direct material spend, while 26% spend less than 5% on renewables	Most input materials are recyclable and durable (e.g. steel) and the use of recycled material is fairly common
	Indirect materials	High	73% of companies spend less than 50% of their indirect material spend on recyclable/renewable materials, and none of the companies spend more than 80%	Only some companies use sustainable indirect materials in production, such as renewable energy or recycled packaging materials
2	Availability	Medium	59% of companies report that their products are idle for less than 20% of the time, while 23% report that the products are idle more than 80% of the time	Even though there is a high available time of products, some products are often not utilised due to seasonal downtime. Also, all companies do not operate on a 24/7 basis
	Operational fit	Very low	46% of companies fully customise their products to meet customer needs and requirements, while 38% meet customer expectations with a standard solution	The majority of the products are designed to fit customer needs and requirements, e.g. in terms of operational efficiency
3	Lifetime	Low	54% of companies report that their products last for over 20 years, while another 21% report that their product lifecycle is 11-20 years long	Most products are built for long lifecycles with high durability
	Functionality	Low	For 42% of companies the share of revenues coming from products that are designed for a long life is 80%, while 26% of the companies have a share of long-life revenue below 10%	Products are designed to be long-lasting – however, design for enhanced reparability, modularity and upgradeability is limited and therefore reduces the lifespan of a product
	Waste in production	High	33% of companies recycle over 80% of their production waste. However, 56% of companies say they recycle less than 50%	Many companies report that in general their level of production waste is very low. Still, there are companies with limited efforts in addressing
4	Take-back	Very high	For 68% 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	Medium	22% of companies recycle over 80% of products at end-of-life. Nevertheless, 56% say that they recycle less than 50% of products	While product recycling rates are high for some companies, the majority of the companies have lower recycling rates
	After-sales	High	For 71% 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	High	60% 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

Source: Analysis based on output from Nordic Circular Industries workshops. More detailed information on the output in Appendix 1.

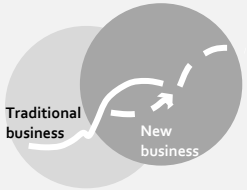
Did you know? On the Circular Economy site, there is an exercise package called **Business model development toolkit**, where you can make the same analysis for your company.

Companies might take different approaches when working with the circular economy based on the company structure and goal

Established manufacturing companies



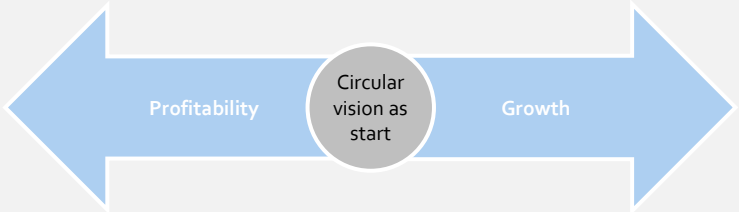
Established manufacturing companies often approach the circular economy through adjusting their traditional business while in parallel exploring new circular business opportunities.



Profitability: increasing resource efficiency of existing production, assets, and infrastructure.

Growth: identify new revenue streams along the product lifecycle or product lifecycle through services, second life sales or recycling.

Start up companies



Start up companies often start with a circular value proposition from the start.

Profitability: establish resource efficient assets from the beginning, leveraging partnerships to enable focus on core activities.

Growth: scaling to expand offerings to new markets and customers with a high focus on customer engagement and feedback.

Five business models reduce the inefficiencies and create value for companies

Reform use of resources

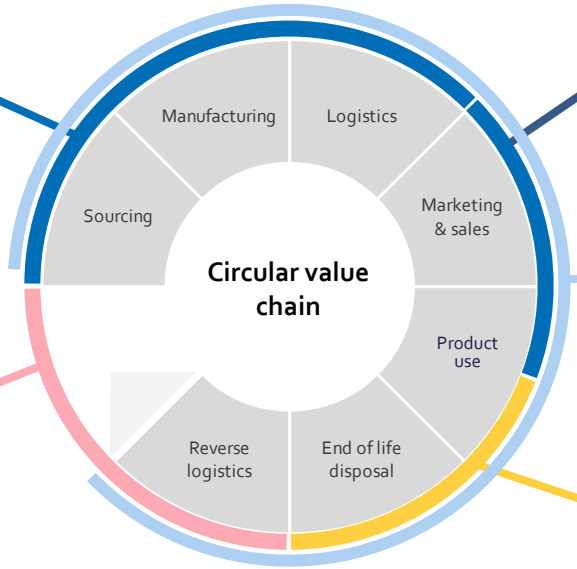
CIRCULAR INPUTS

Use of renewable energy, bio-based or potentially completely recyclable materials and design products that are durable and easy to repair

Recover value in waste

RESOURCE RECOVERY

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 lifecycle

Extend lifecycles

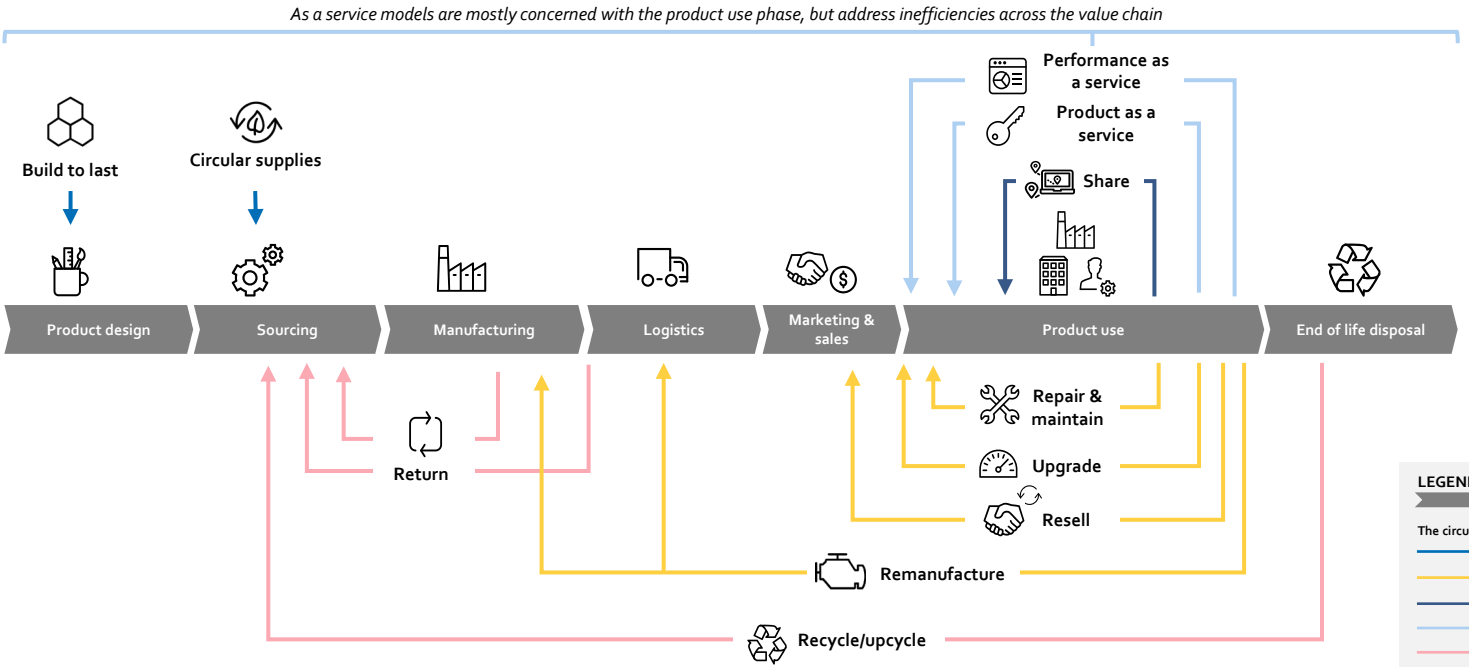
PRODUCT USE EXTENSION

Extension of the lifecycle 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 analyze 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



Additional circular business models

Circular inputs
- Recycled direct materials
- Sustainable indirect materials

Sharing platform
- Virtual sharing platform
- Physical sharing platform

Resource recovery
- Recover
- Downcycle

Product use extension
- Restore
- Repurpose
- Refresh

LEGEND
- Linear value chain

The circular economy value chain
- Circular inputs
- Product use extension
- Sharing platform
- Product as a service
- Resource recovery

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, maritime, 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 INPUTS	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 USE 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
RESOURCE RECOVERY	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

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

Source: Analysis based on output from Nordic Circular Industries workshops. More detailed information on the output in Appendix 1.

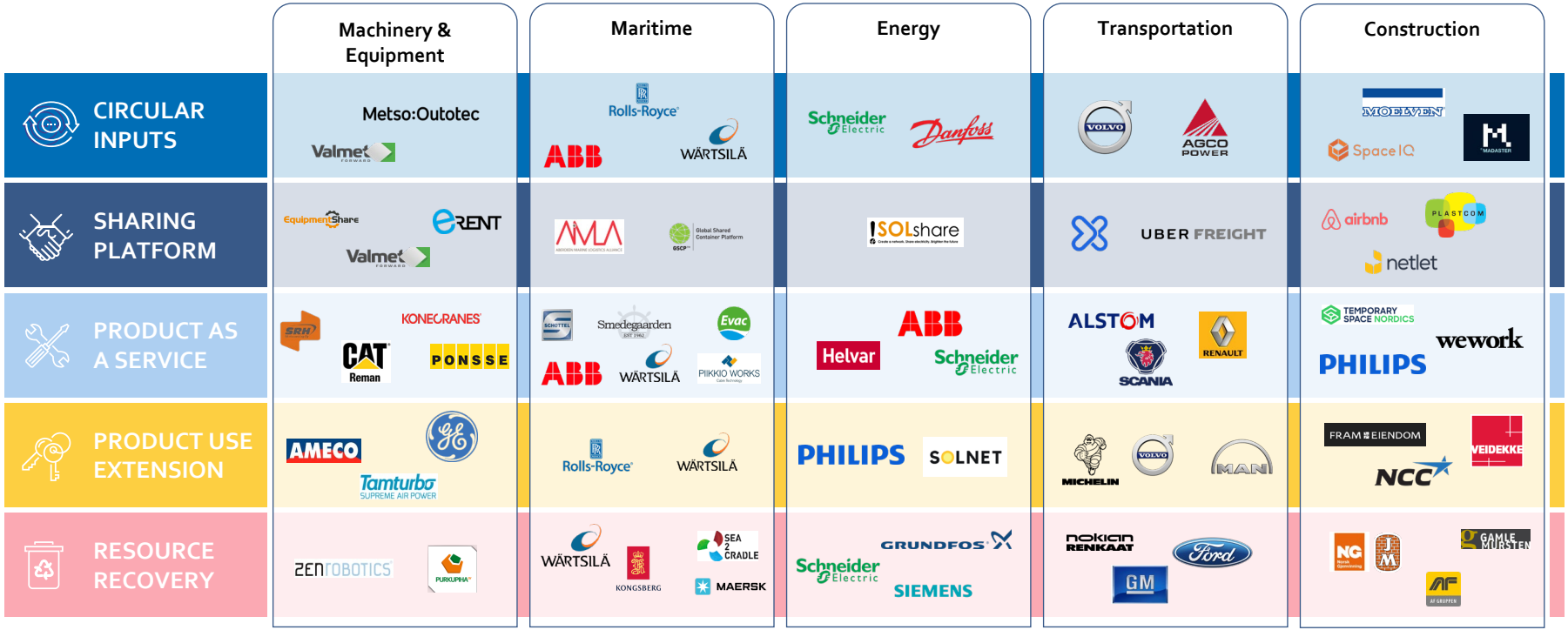
Current adoption level of circular models in the Nordic manufacturing industry is highest within circular inputs and product use extension

Business model	*Sub-model*	*Adoption level*	*Comment*
CIRCULAR INPUTS	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, but being explored
	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, as many of the products are fixed installations or have a high degree of customization
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. Some companies are finding it challenging to find an investment model and achieve a win-win situation for both customers and the company
	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 USE 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
RESOURCE RECOVERY	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, the products are not built for circularity and it is difficult to separate materials and even know the product composition
	Return	Not applied at all — Widely applied	Most companies recycle some of their manufacturing waste

Source: Analysis based on output from Nordic Circular Industries workshops. More detailed information on the output 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.

Compelling examples from Nordic and global manufacturing companies



Source: Accenture, Appendix 2 for more details, Company websites

The circular economy business models can boost bottom line results for manufacturing companies through reduced cost and increased revenue

CIRCULAR INPUTS	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 AS A SERVICE	Product as a Service	Increase revenues	Michelin sells tires-as-a-service with **a revenue potential of 3bn€ in 10 years**
PRODUCT USE 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
RESOURCE RECOVERY	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

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 the circular economy business models for your company.

Ørsted is decarbonizing their offshore wind production

About

- The Danish energy company Ørsted develops, constructs and operates offshore and onshore wind farms, solar farms, energy storage facilities, and bioenergy plants, and provides energy products to its customers

Background

- Ørsted has transitioned to become a world leading energy company in green wind-power solutions for both offshore and onshore installations
- The company has set a target to reduce emissions from their supply chain by 50% by 2032 and then down to net-zero emissions by 2040
- The largest emissions from the supply chain are coming from the manufacturing of wind turbines, foundations, substations and cables and from the maritime vessels transporting and installing offshore wind components

How they are working with circular inputs

- Ørsted has initiated a three-step approach to decarbonize the offshore wind farm supply chain and operations (1) require science-based reporting from suppliers, (2) require renewable energy sources for producing wind farm components and (3) move towards 100% renewable wind farm operations fleet
- Embedded in this approach is a close engagement with strategic suppliers. Together with each strategic supplier, Ørsted is designing an individual roadmap on how the supplier can deliver the required carbon reductions in a competitive market
- Currently, many of the low-carbon technologies are not yet cost-efficient or available at scale. One of the goal's with the supplier engagement is to generate a demand for low-carbon solutions and contribute to driving scalable and cost-efficient solutions in the market

Source: Company website

Case study

Circular inputs

Value realized

- Actively engagement with suppliers to reach carbon neutrality
- Promoting investment in low-carbon technologies

Konecranes is offering material handling system as a service

About Konecranes

- Konecranes is a Finnish manufacturer and service provider of cranes, lifting equipment and material handling products.
- In 2013, Konecranes launched a material handling system as a service. The system handles smaller materials such as tools, spare parts and packages.

Drivers

- Konecranes experienced two key drivers from their customers that lead to the introduction of the system
  - Firstly, the system is easy to buy for the customers as major up-front investment costs in the equipment is avoided. Instead, the customers pay a monthly fee.
  - Secondly, the lifecycle risk of owning equipment is eliminated as the leasing agreement can be terminated if there are any changes in demand and the service of the equipment is handled by Konecranes.

How Konecranes is working with product as a service

- The solution consists of a closed unit shelving system, robots travelling within the shelving and an online portal where the customer can remotely track stock information. The material handling system is module based. The system can be adjusted to the customer's volume, e.g. adding modules if they are experiencing a ramp up in volumes.
- In addition, a dedicated Konecranes team performs continuous remote monitoring of the system. In the case of system failure, the service team replaces the defect module with a replacement module. Further diagnostics of the defect module is conducted at a Konecranes service center, ensuring minimum downtime on the site.
- Konecranes leveraged their existing service capabilities and culture when launching this initiative. However, they had to develop a new way of working with remote monitoring as this is one of the key offering of the service, ensuring that the team had both a customer focused and engineering mindset.

Source: Interview

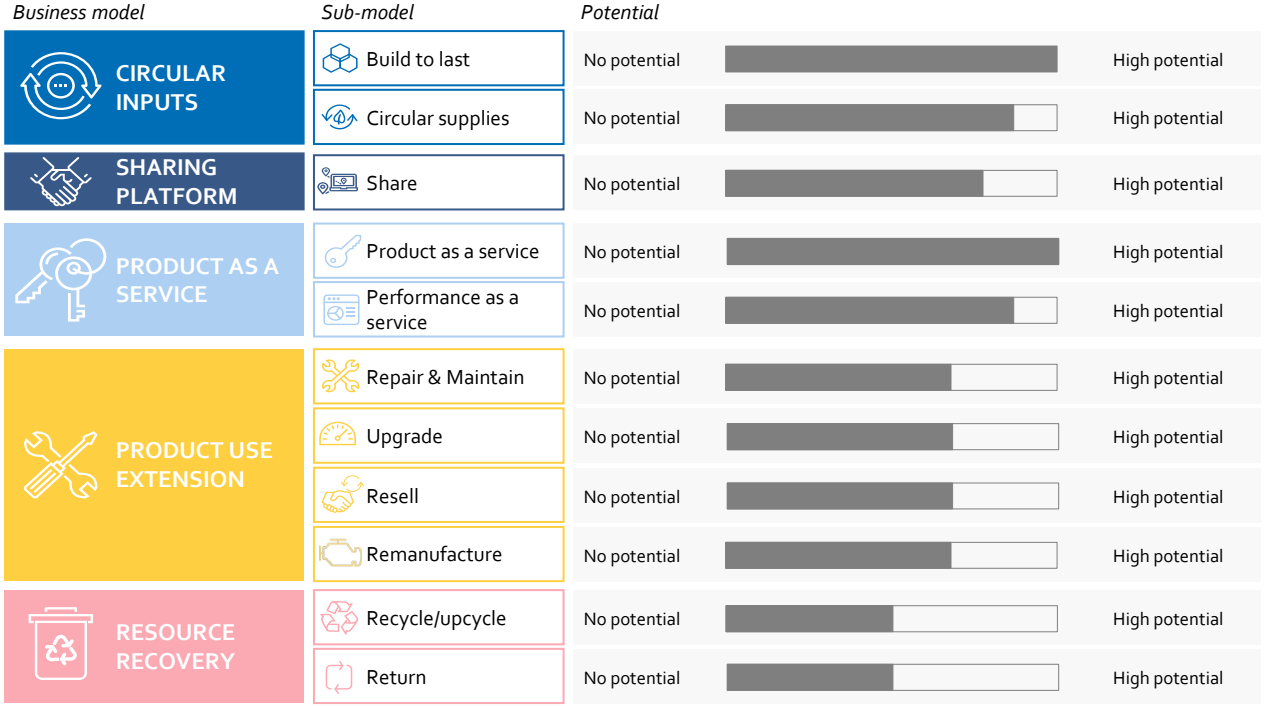
Case study

Product as a service

Value realized

- Prolongs the lifetime of the product by e.g. reusing components
- Increases the safety of the workers through closed units
- Easy for customers to buy and use

Build to last and product as a service are evaluated as the most promising circular opportunities by Nordic manufacturing companies



Comments

Circular inputs, product as a service and sharing platform are evaluated as the business models with the highest future potential.

- **Build to last** is currently widely adopted by Nordic manufacturing companies, but further potential lies in looking towards more modular design, designing products for multiple lifecycles and for recycling
- Companies are increasingly exploring **as-a-service** models and evaluate these as promising opportunities
- **Sharing platforms** are currently among the least adopted models due to fixed or highly customized products, but companies find a high potential in sharing platforms for support functions such as logistics services, and for information sharing between actors in the value chain

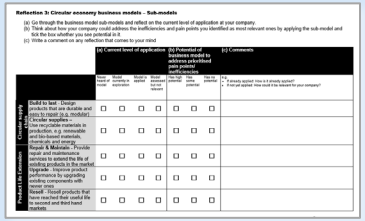
Source: Analysis based on output from Nordic Circular Industries workshops. More detailed information on the output in Appendix 1.

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

1

Business model development toolkit

Set of exercises for identifying inefficiencies and customer pain points, assessing relevance of circular business models, and prioritising them

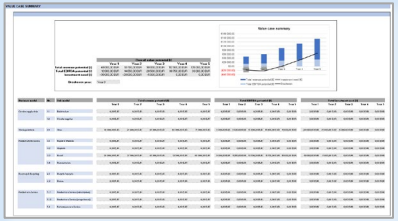


Estimated working time: 30-60 min

2

Value case assessment tool

Tool for calculating high-level business case for circular business models



Estimated working time: 60 min

What opportunities exist?
Business model canvas

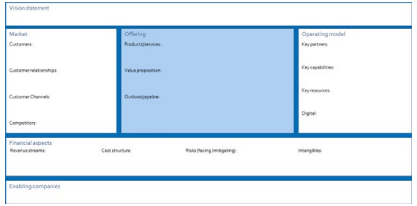
Key questions

1. What are the key sources of waste and inefficiencies in your company's value chain?
   - Hazardous R&D
   - Unsustainable raw materials
   - Hazardous manufacturing by-products
   - Unsustainable energy sources or high energy consumption in manufacturing
   - Unrecovered materials from end-of-life products
2. Which sustainable and circular business models would be the most relevant to address those waste streams and inefficiencies? How?
3. What kind of benefits do you expect to get from these new business models? How large are they in quantitative terms?
   - Revenue generation
   - Cost savings
   - Brand enhancement
   - Risk mitigation

Business model canvas

Based on the information learnt in this chapter, fill in the following parts of the business model canvas:

- **Offering –** detail what the solution you want to offer could look like, what the concrete value propositions to your customers is and draft an outlook on how it could be developed further or what other solutions could be connected with it



3 Which capabilities are required?

Introduction to organizational 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 organization 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 organization in several functions, including for example R&D, procurement and sales

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

Linear value 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 lifecycle management services
- Improved understanding of customer and product requirements can be achieved through continuous interactions and data analytics

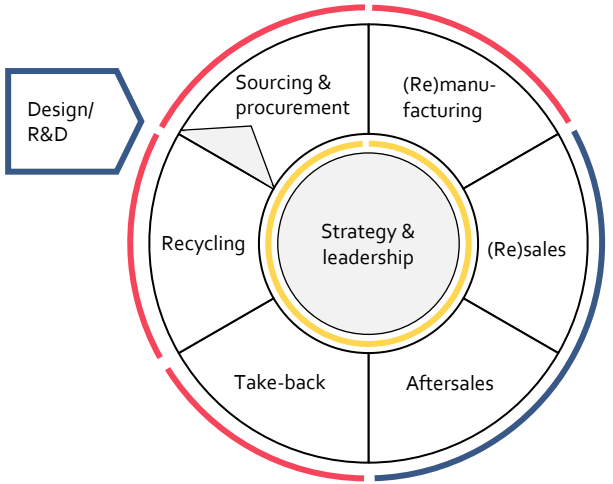
B) Resource handling

- 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

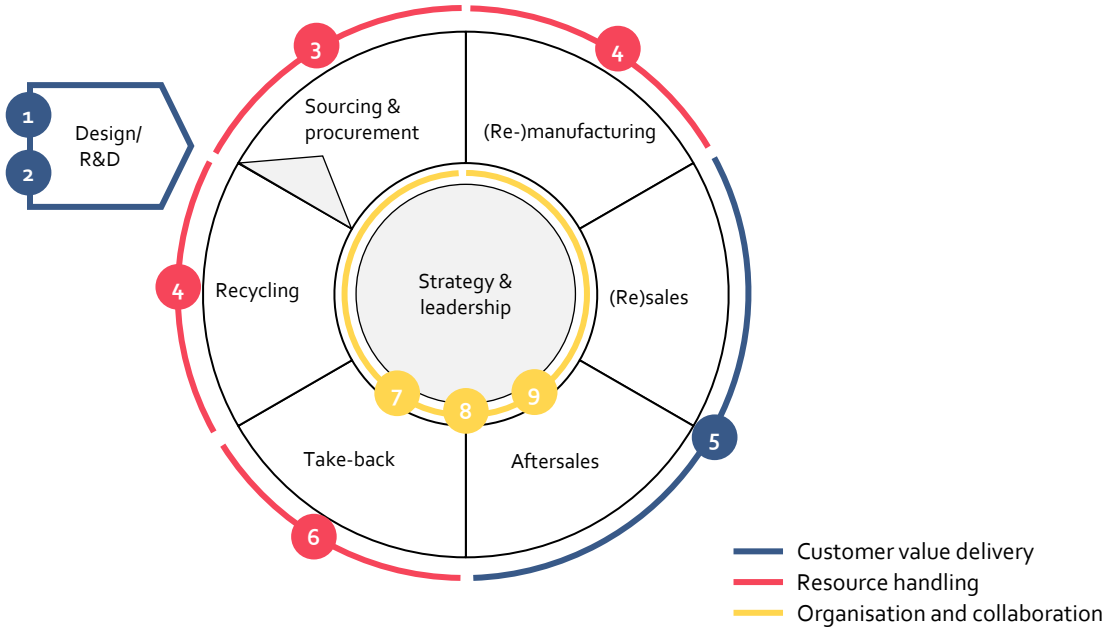


Source: Accenture, Appendix 2 for more details

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

Capabilities

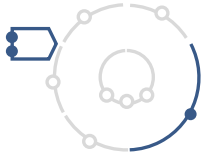
1. Design solutions to deliver customer outcomes
2. Design products for circularity
3. Source recycled or recyclable material
4. Produce, remanufacture and recycle products
5. Sell outcomes and lifecycle services
6. Take back products at end-of-life
7. Deploy technologies and data for delivering outcomes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



Source: Accenture, 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.

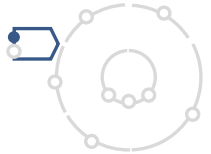
Customer-centric design enables additional sales throughout the product lifecycle



	Design solutions to deliver customer outcomes	Design products for circularity	Sell outcomes and lifecycle services
	Design/ R&D, S&P, (Re)manu-facturing, Sales, Aftersales, Take-back, Recycling, Strategy & leadership	Design/ R&D, S&P, (Re)manu-facturing, Sales, Aftersales, Take-back, Recycling, Strategy & leadership	Design/ R&D, S&P, (Re)manu-facturing, **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 lifecycles and sustainable material use** • Understanding of environmental impact throughout product lifecycles • Ability to design products that are durable, easy to repair and upgrade, and use materials sustainably	**Ability to leverage customer insights to sell value-adding solutions** • Ability to engage customers and use customer insights for sales throughout product lifecycles • Developing new offering and pricing models for outcome-oriented solutions • Understanding of customer demand and changing needs across product lifecycles
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 • Develop smart products	**Follow circular design principles in product design** • Perform lifecycle 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 track materials throughout product lifecycles	**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 use 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

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



Design solutions to deliver customer outcomes

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 lifecycle management (DPLM or ALM[2])**
   Include the design of the complete digital lifecycle into the initial design phase. The DPLM enables to speed up processes and increase efficiencies throughout the lifecycle by digitising and coordinating all relevant processes connected to the solution. Product lifecycle 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 inputs	Sharing platform	Product use extension	Resource recovery	Product as a service
✓	✓	✓	✓	✓

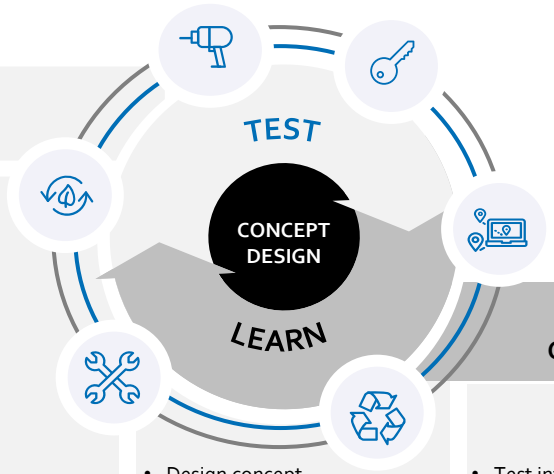
1 Digital Product Lifecycle Management 2 Application Lifecycle Management

Design/ R&D | Sourcing & procurement | (Re)manu-facturing | Sales | Aftersales | Take-back | Recycling | Strategy & leadership

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

Design solutions to deliver customer outcomes

Piloting approach

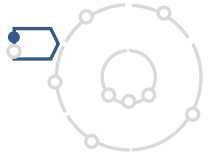


CUSTOMERS	NEEDS		SERVICES & CAPABILITIES	ECOSYSTEM PARTNERS
• Discover customer needs through market research (e.g. questionnaire) and customer workshop • Deploy design thinking methodology to create a prototype and minimum viable product for fast market testing and iterative refinement	• Describe circular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

Improved user experience and enhanced ability to deliver solution

Design/ R&D | Sourcing & procurement | (Re)manu-facturing | Sales | Aftersales | Take-back | Recycling | Strategy & leadership

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



Design solutions to deliver customer outcomes

Changes from traditional to service innovation

	Product innovation	Service innovation
What	Understand customer usage and expected product attributes	Design and live customer experience or 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 or analytics
Duration	Perform innovation cycle in years	Perform innovation cycle in weeks or months

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

Design solutions to deliver customer outcomes

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

Lifecycle thinking and circular design criteria are key in developing circular products

Design products for circularity

Required know-how and activities

1. **Lifecycle thinking**
   Consider the whole lifecycle 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 ycle thinking

Minimizing environmental impacts along the whole lifecycle and comparing alternatives against each other are key for sustainable product design. **Lifecycle 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

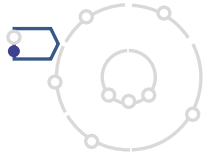
- % of renewable, recycled or reused material in product
- # of different components in product design

Business model relevance

Circular inputs	Sharing platform	Product use extension	Resource recovery	Product as a service
✓		✓		✓

Design/ R&D | Sourcing & procurement | (Re)manu-facturing | Sales | Aftersales | Take-back | Recycling | Strategy & leadership

Seven aspects are relevant for circular design



Design products for circularity

Aspect	How to incorporate it in a product	Example
1 **Design out waste**	Use less resources for producing the product	Volvo Trucks produces 3D printed tools and fixtures to reduce use
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 lifecycle**	Make sure product is efficient in use phase (e.g. no resource intensive supplies)	Metso 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

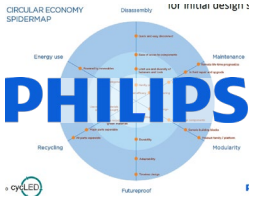
Several companies have good practices in circular product development, such as use of modular design

Design products for circularity

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

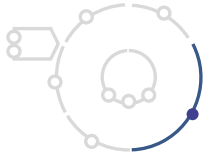
Example: Philips offers design guide for product development with CE Spider Web in which solutions are rated for Disassembly, Maintenance, Modularity, Futureproof, Recycling and Energy use (Link to tool description)

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

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



Sell outcomes and lifecycle services

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 lifecycle:** 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 use extension support:** Provide services for product use 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

Source: Company websites

Guidance on product use 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

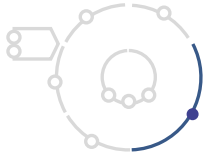
- Level of customer satisfaction
- Average duration of customer relationships
- % of solutions sold (instead of product-only)

Business model relevance

Circular inputs	Sharing platform	Product use extension	Resource recovery	Product as a service
☐	✓	✓	☐	✓

Design/ R&D | Sourcing & procurement | (Re)manu-facturing | Sales | Aftersales | Take-back | Recycling | Strategy & leadership

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



Sell outcomes and lifecycle services

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 lifecycle	**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

Low ○ ◔ ◑ ● High

1 Product as a Service

Companies are using new pricing models and are applying digital technologies

Sell outcomes and lifecycle services

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 for example 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 use extension support
Offer a range of after-sales services to prolong the lifetime of the product

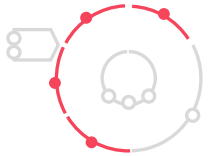
Example: Vestas offers a range of repair and upgrade services to their wind turbines. As wind technology matures, turbines already in operation can be upgraded to yield more energy and thereby improve an existing wind park business case

Enabling technology

Digital infrastructure

Source: Company websites

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



	Source recycled or recyclable material	Produce, remanufacture and recycle products	Take back products at end-of-life
	Design/ R&D · S&P · (Re)manu-facturing · Sales · Aftersales · Take-back · Recycling · Strategy & leadership	Design/ R&D · S&P · (Re)manu-facturing · Sales · Aftersales · Take-back · Recycling · Strategy & leadership	Design/ R&D · S&P · (Re)manu-facturing · 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	**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	**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	**Access circular materials from new sources:** • Collection infrastructure & external take-back • Industrial symbiosis • Source marketplace platform • Waste company partnership • Commodity market for secondary materials	**Integrate technologies to monitor and track material and product flows** • Track production process and materials with tags (e.g. RFID), Machine vision and AI • Automatically sort materials (e.g. robotics) • Assess performance and address only faulty functionality and components	**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 lifecycle

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

Source recycled or recyclable material

Required know-how and activities

1. **Circular materials and equipment:** Make products or 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 the 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 the 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 inputs	Sharing platform	Product use extension	Resource recovery	Product as a service
✓		✓		✓

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

Design/ R&D | Sourcing & procurement | (Re)manu-facturing | Sales | Aftersales | Take-back | Recycling | Strategy & leadership

Circular resource marketplace platforms and industrial symbiosis can transform material sourcing

Source recycled or recyclable material

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: **Netlet** picks up surplus material from construction sites free of charge. This eases the construction firm's ability to keep up with increasingly strict regulations regarding recycling and waste disposal. Netlet makes this surplus material available through both physical stores and through their online platform. Both companies and consumers can use the service, and all material is sold at a discounted price and is contributing to reducing waste in the construction industry*

Industrial symbiosis (IS)
Develop symbiotic partnerships with cross-industry actors designing "waste as input" streams

*Example: **Kalundborg** (Denmark) – Collaboration with 12 private and public partners started in 1970s. Has about 20 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

Digital infrastructure

Source: Company websites

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

Source recycled or recyclable material

Good practices and examples

3D HUBS

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)*

Enabling technology

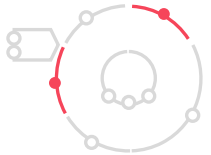
3D printer

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

Example: HP includes the 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."

Source: Company websites

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



Produce, remanufacture and recycle products

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

Business model relevance

Circular inputs	Sharing platform	Product use extension	Resource recovery	Product as a service
☐	☐	✓	✓	✓

Design/ R&D | Sourcing & procurement | (Re)manu-facturing | Sales | Aftersales | Take-back | Recycling | Strategy & leadership

To raise resource efficiency, use robotics, keep waste separated and introduce remanufacturing

Produce, remanufacture and recycle products

Good practices and examples

Robotics
Robotics in the production process reduces waste of material, while increasing efficiency

Example: Eentileen use a building software to transform a 3D design into production data. Robots cuts sustainable source plywood based on the digital blueprint

Enabling technology

Robotics

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

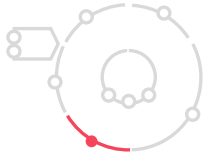
Example: Ford engages with suppliers to recycle aluminium scraps from car production (e.g. stamping windows into body panels). To achieve the required level of purity, Ford invested in machinery to separate, clean and shred aluminium

Remanufacturing capabilities
Develop remanufacturing capabilities to sort and repair returned equipment to extend their lifecycles

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

Source: Company websites

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



Take back products at end-of-life

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 lifecycle 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

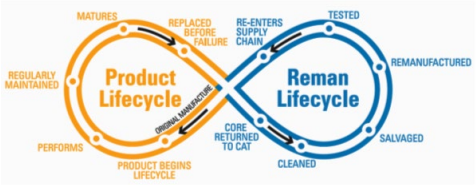
Circular inputs	Sharing platform	Product use extension	Resource recovery	Product as a service
☐	✓	✓	✓	✓

Design/ R&D | Sourcing & procurement | (Re)manu-facturing | Sales | Aftersales | **Take-back** | Recycling | Strategy & leadership

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

Take back products at end-of-life

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: AF has developed new technology to harvest, clean and recycle contaminated construction materials, extracting 80% of the mass as reusable materials and 20% as contaminated mass for further treatment

Source: Company websites

Excess resource streams from geothermal power plants are being used by a range of companies

About

RESOURCE PARK

- HS Orka is an Icelandic energy company operating two geothermal power plants producing electricity and hot water
- A resource park has been developed to encourage increased and more efficient utilization of what the geothermal plants produce

Background

- The objective of the resource park is to foster a "society without waste"
- The resource park has been established in the neighborhood of the geothermal plants and other businesses have co-located with the powerplants to use the co- and by-products
- Each of the companies of the resource park directly utilizes two or more resource streams from the geothermal plants

How they are working with unconventional use of resources

- A spa and skin care clinic uses the geothermal fluid for a prime tourist attraction and to produce skin care and health products. Two more companies use the steam to process fishery by-products into dried fish products and high-value fish oil. Another company produces methanol using the waste CO_2. A biotechnology company heats its greenhouses with heat provided by the power plants to make growth factors for medical research and skin care products
- Other products and operations of the resource park include farming warm-water flat fish, natural treatment of skin disorders, algae farming, eco-friendly cosmetics with active substances from the area, hot and cold groundwater, steam, geothermal fluids etc.
- In addition to 30 jobs at the power plants, more than 1000 jobs are estimated to have been created in the resource park

Design/ R&D | Sourcing & procurement | (Re)manu-facturing | Sales | Aftersales | Take-back | Recycling | Strategy & leadership

Case study

Design & R&D
Sourcing & procurement

Value realized

- Increased utilization of side streams from the geothermal plants
- Generation of more than 1000 jobs in connection to the resource park

Source: Company website

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

Organization and collaboration

	Deploy technologies and data for delivering outcomes	Orchestrate ecosystem of partners	Transform culture and steering
	Design/ R&D · S&P · (Re)manu-facturing · Sales · Aftersales · Take-back · Recycling · **Strategy & Leadership**	Design/ R&D · S&P · (Re)manu-facturing · Sales · Aftersales · Take-back · Recycling · **Strategy & Leadership**	Design/ R&D · S&P · (Re)manu-facturing · 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 lifecycle 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, the Ellen MacArthur Foundation and DIMECC Ltd) • Build digital platforms to connect to stakeholders and to gain insights	**Integrate the 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 utilization of internal and external strengths and resources

[1] Intellectual Property Rights

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

Deploy technologies and data for delivering outcomes

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 monetization

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

Business model relevance

Circular inputs	Sharing platform	Product use extension	Resource recovery	Product as a service
✓	✓	✓	✓	✓

Design/ R&D | Sourcing & procurement | (Re)manu-facturing | Sales | Aftersales | Take-back | Recycling | Strategy & leadership

Good practices include deploying technologies and drawing insights from generated data

Deploy technologies and data for delivering outcomes

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

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

Orchestrate ecosystem of partners

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 lifecycle
- # of ideations with eco-system partners

Business model relevance

Circular inputs	Sharing platform	Product use extension	Resource recovery	Product as a service
✓	✓	✓	✓	✓

Design/ R&D | Sourcing & procurement | (Re)manu-facturing | Sales | Aftersales | Take-back | Recycling | Strategy & leadership

Harness existing networks and partnerships and use digital platforms for interaction

Orchestrate ecosystem of partners

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 the Ellen MacArthur Foundation Network are initiatives that aim to accelerate the transition to the 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

Build the capability to manage the transformation at the right pace

Transform mindset and steering

Required know-how and activities

1. **The 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 lifecycle 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:** Lifecycle emissions [e.g. CO_2 volume]
- **Sourcing:** % of input coming from virgin vs recycled materials
- **Manufacturing:** % of reused materials or 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 inputs	Sharing platform	Product use extension	Resource recovery	Product as a service
✓	✓	✓	✓	✓

Design/ R&D | Sourcing & procurement | (Re)manu-facturing | Sales | Aftersales | Take-back | Recycling | Strategy & leadership

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

Transform mindset and steering

Good practices and examples

Target setting
Integrate the 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 the 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

Electrolux is linking financial incentives to delivery on sustainability targets

About

- Swedish multinational manufacturer of home appliances, ranked the second largest appliance maker in the world
- Electrolux products sell under a variety of brand names and are primarily intended for consumer user, but they also make appliances for professional use

Background

- Electrolux is working towards climate neutral operations by 2030 and a climate neutral value chain by 2050
- In 2019, they joined the UN Business Ambition for 1.5°C pledge, a global movement of business leaders working toward zero emissions by 2050, in line with the Paris Agreement
- Electrolux is making an important contribution through its ongoing investment programs for cooling appliances – to reduce the climate impact of its factories and products

How they are working with strategy & leadership

- In 2020, Electrolux took the commitment a step further by linking financial incentives to delivery on sustainability targets, 20% of the annual share-based incentives for Electrolux' 300 top leaders will be based on how effectively they have managed to reduce CO_2 emissions
- Electrolux was one of the first 100 companies in the world to set science-based targets to reduce emissions in support of the Paris Agreement. The metrics from these targets will be used to link sustainability performance with their Long-Term Incentive (LTI) program
- For participants to receive their maximum LTI payout, Electrolux must achieve certain tangible CO_2 emission reductions within manufacturing, product usage and from phasing out the usage of high-impact greenhouse gases in appliances over the coming three years

Design/ R&D | Sourcing & procurement | (Re)manu-facturing | Sales | Aftersales | Take-back | Recycling | Strategy & leadership

Case study

Strategy & leadership

Value realized

- Tangible science-based targets to reduce CO_2 emissions
- Leadership incentives clearly linked to CO_2 emission reductions

Source: Company website

Ruter is working with the circular economy through offering end-to-end mobility solutions

About

Ruter#

- Norwegian public transport company responsible for planning, coordinating, ordering and marketing public transport. All transport services are performed by various operators

Background

- Ruter's strategy is to offer mobility solutions to all citizens that are sustainable for the environment, society and customers
- They are seeking to support a sharing economy by ensuring that citizens can travel wherever they want, whenever they want with the extended public transport network, instead of using their own cars

How they are working with strategy & leadership

Ruter is promoting their mobility services through several areas. Two of these are the mobility ecosystem and data driven operations:

- **Mobility ecosystem**: Ruter is collaborating with other mobility players to create an end-to-end offering to their customers (e.g. collaboration with car sharing, taxi, bicycles, scooters). One example is the pilot collaboration with Bærum municipality and the micro-mobility provider TIER. Travelers will be offered electrical bicycles and scooters as complementary to the existing public transport system to allow them to travel from a public transport hub to their end destination
- **Data driven operations:** Technology is seen as a key enabler for sustainable mobility. Technology can be used to e.g. 1) Capture data on position, speed, number of passenger, remaining travel time etc. to optimize the capacity of the vehicles 2) Understand travels behavior and use nudging to influence how they travel (e.g. influence them to travel when there is less passengers) and 3) Share relevant travel data with other actors in the mobility ecosystem to ensure an end-to-end offering

Design/ R&D | Sourcing & procurement | (Re)manu-facturing | Sales | Aftersales | Take-back | Recycling | Strategy & leadership

Case study

Strategy & leadership

Value realized

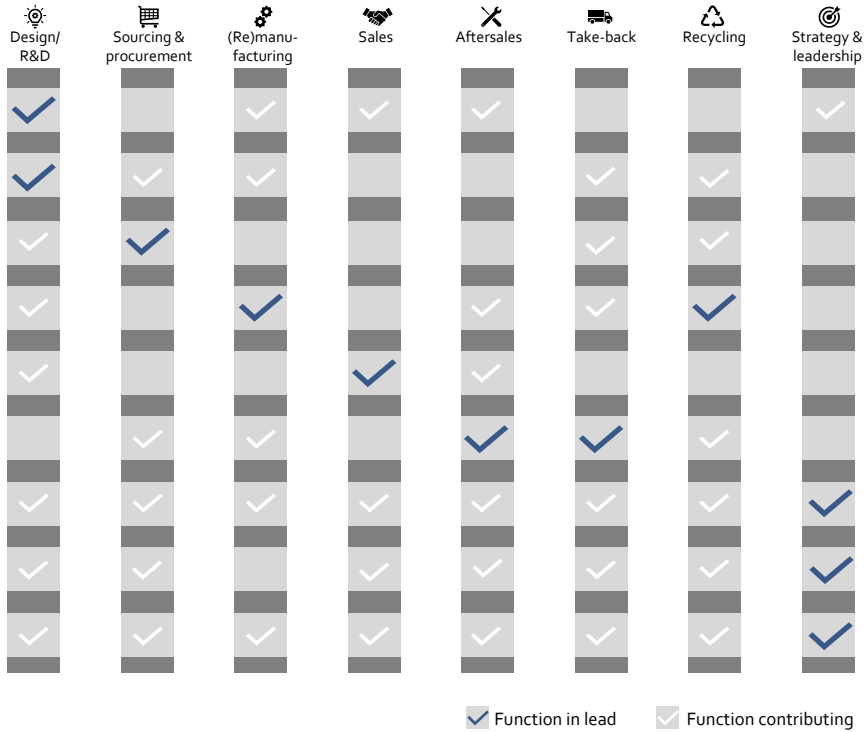
- Lower environmental footprint of the region by reducing the number of cars in the region

Source: Interview

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

Capabilities

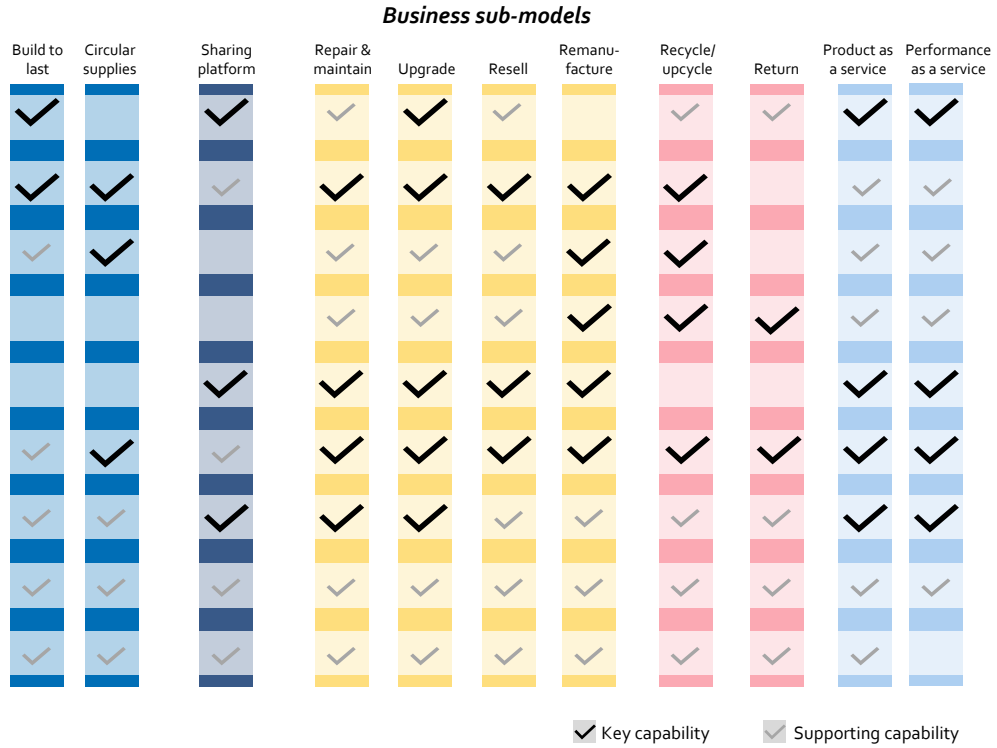
1. Design solutions to deliver customer outcomes
2. Design products for circularity
3. Source recycled or recyclable material
4. Produce, remanufacture and recycle products
5. Sell outcomes and lifecycle services
6. Take back products at end-of-life
7. Deploy technologies and data for delivering outcomes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



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



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

Illustrative

1 Design solutions to deliver customer outcomes
- Providers of digital technologies
- Companies supporting on digital product lifecycle 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
- 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 the circular economy

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

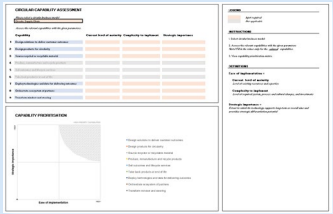
Customer value delivery
Resource handling
Organisation and collaboration

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

1

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



Estimated working time: 15 min

Which capabilities are required?
Business model canvas

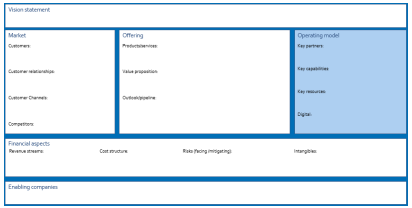
Key questions

1. Considering the key capabilities that companies need to mature in to succeed in circularity, what kind of development initiatives should your company start?
2. What are the key actions required to make these initiatives happen?
3. Who are the key partners you need to collaborate with?

Business model canvas

Based on the information learnt in this chapter, fill in the following parts of the business model canvas:

- **Operating model** – reflect on key partners and capabilities needed to operate



4 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 the circular economy in the manufacturing industry
- Industry x.0 summarizes the rapid development of digital, physical and biological technologies, providing levers for circularity
- Companies can draw on a set of 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 the 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

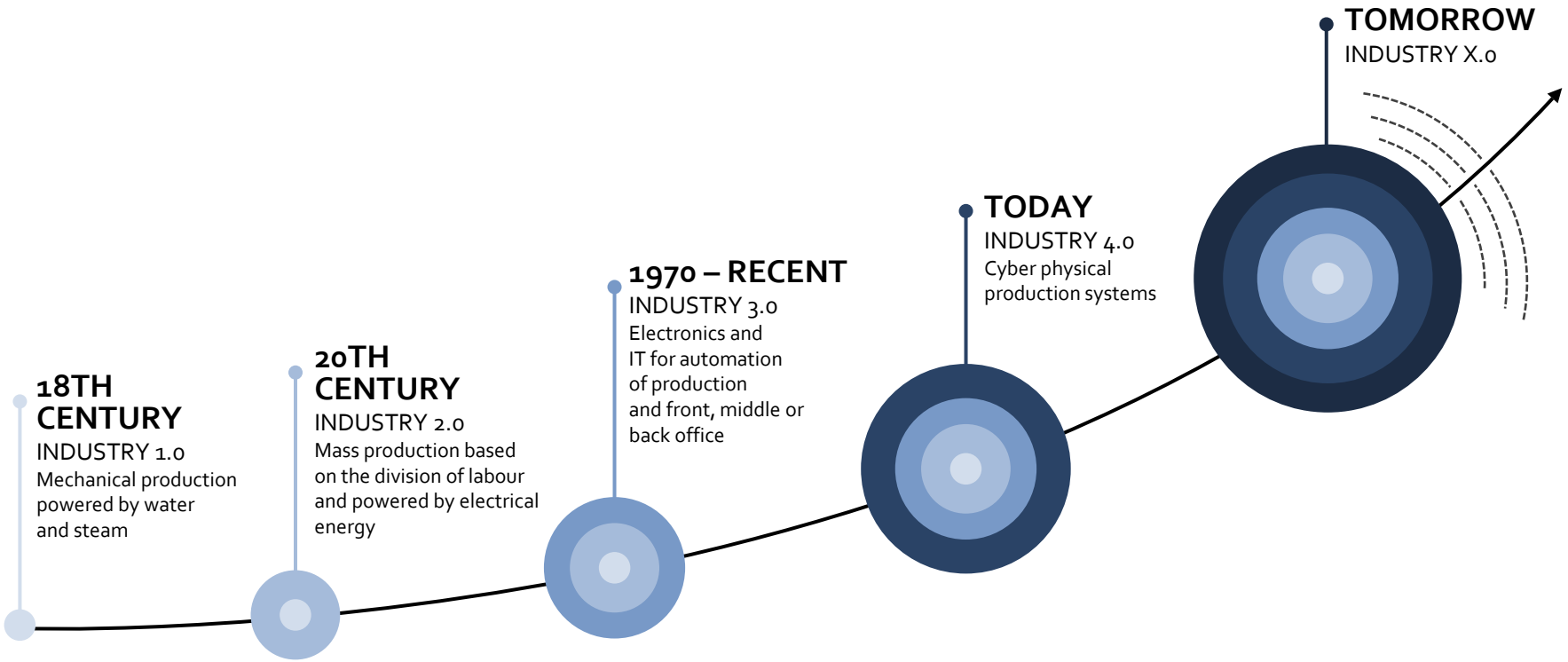
"Predictive maintenance in performance contracts is not a novel development at the enterprise level. However, recent technological development increasingly enables performance models to trickle down to small and medium-sized enterprise (SME) customers where previously the tracking and logistics were 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

New services & experiences for customers and workforce

Acceleration & efficiency in production and solutions

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

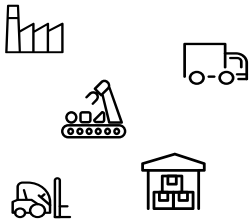
Outcome for companies

- **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

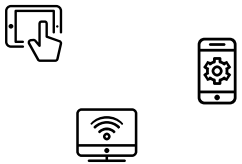
Accumulation of data is increasing and is opening new opportunities for companies to derive value

Data captured via IoT sources



Sensors or embedded chips on products and assets (e.g. machinery, buildings, vehicles) that record performance data or usage data

Data captured via transactional information management systems



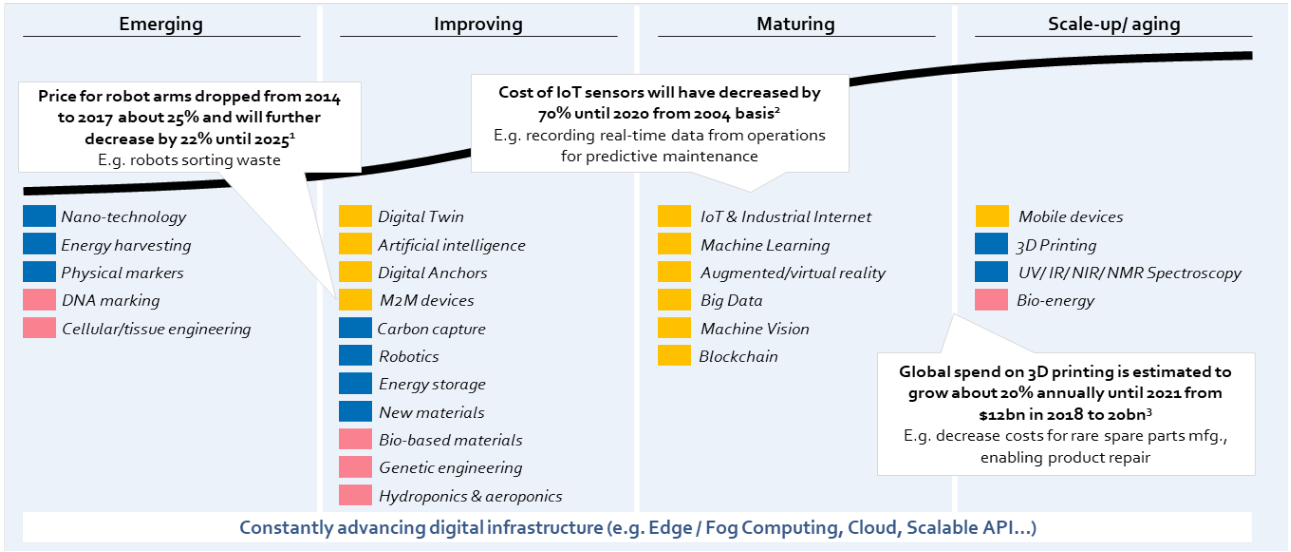
Transactional information technology systems (e.g. customer relationship management, enterprise resource planning) that can record maintenance incidents or logistics activity

Examples of use cases for the combined and aggregated data

- A manufacturer instruments the equipment and employ the sensors to gather performance data. The manufacturer uses the data to offer services to their customers, e.g. remote diagnostics
- The manufacturer employ the sensors to gather information on how their customers typically operate the equipment (e.g. speed, running intervals). The manufacturer uses the operational data to advise the customer on the most optimal way of operating the equipment
- A manufacturer uses data collected in a disassembly processes at the end of life of a product in the design process of the new product to optimize the disassembly process

The data from IoT and information technology system sources are aggregated and analysed to **generate new opportunities both within one individual company or between a company and its customers and suppliers**

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



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

Type of technology: Digital | Physical | Biological

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

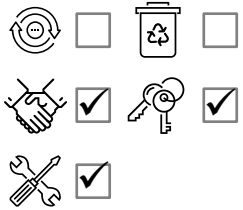
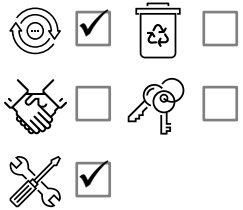
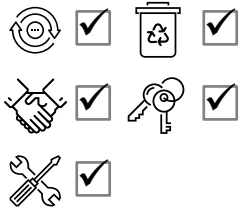
Did you know? On the Circular Economy site, there is a **technology maturity assessment**, with which you can assess the maturity of your company in technologies enabling circularity and identify actions to develop it.

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

	Technologies	Circular inputs	Sharing platform	Product use extension	Resource recovery	Product as a service
Scale-up/aging	Mobile devices	☐	☑	☑	☐	☑
	3D printing	☑	☐	☑	☐	☐
	UV/IR/NIR/NMR spectroscopy	☐	☐	☐	☑	☐
	Bio-energy	☑	☐	☐	☑	☐
Maturing	Machine learning	☑	☑	☑	☑	☑
	Internet of Things & industrial internet	☑	☐	☑	☐	☐
	Augmented reality/ virtual reality	☑	☐	☑	☐	☐
	Big data	☑	☑	☑	☑	☑
	Machine vision	☑	☐	☑	☑	☐
	Blockchain	☐	☑	☑	☑	☑
Improving	M2M devices	☑	☑	☑	☑	☑
	Carbon capture	☑	☐	☐	☑	☐
	Robotics	☐	☐	☑	☑	☐
	New materials	☑	☐	☐	☑	☐
	Energy storage	☑	☑	☐	☐	☑
	Bio-based materials	☑	☐	☐	☐	☐
	Artificial intelligence	☑	☐	☑	☑	☐
	Digital twin	☑	☐	☑	☐	☑
Emerging	Nano-technology	☑	☐	☑	☐	☐
	Energy harvesting	☑	☐	☐	☐	☐

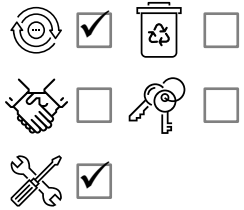
Type of technology: Digital | Physical | Biological

Mobile devices, augmented reality and big data are digital technologies enabling the circular economy

	Technology	Description and circular examples	Illustrative CE value driver	Business model relevance
Scale-up/aging	**Mobile devices** 	Combines hardware, operating systems, networks and software to provide users with real-time access to content *Example: NCC leveraged mobile devices for its "Loop Rocks" platform, which enables smart handling of construction waste. Construction site managers could upload details of excess materials via an app*	Enables direct communication with customers	
Maturing	**Augmented reality/ virtual reality** 	Provides interactive fully immersive digital reality in a computer generated or video enabled environment (VR) or superimpose 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	
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	

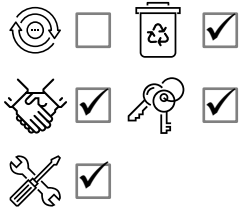
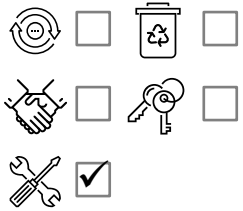
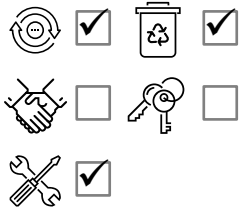
Type of technology: Digital | Physical | Biological

IoT, machine learning and machine vision provide different value drivers for the circular economy

	Technology	Description and circular examples	Illustrative CE value driver	Business model relevance
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 the 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 optimize the turbine´s emissions. The system was able to further reduce emissions by an additional 10-15% after experts´ optimization*	Enables predictive analytics through algorithms and optimization	
Maturing	**Machine vision** 	Provides a computing device with the ability to acquire, process, analyze 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	

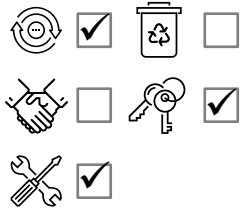
Type of technology: Digital | Physical | Biological

Blockchain, conversational systems and artificial intelligence are further enabling digital technologies

	Technology	Description and circular examples	Illustrative CE value driver	Business model relevance
Maturing	**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 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 process 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	
Improving	**Artificial intelligence** 	Applies a set of technologies like machine analytics, learning and e.g. computer vision that enable machines to simulate human intelligence and act without explicit instructions *Example: AMP recycling system utilises a machine learning, and computer vision driven robotic systems to intelligently sort waste*	Enables process to become more efficient over time	

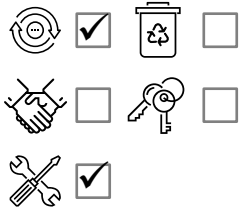
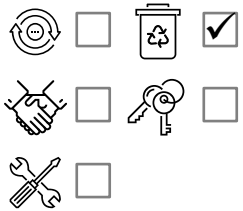
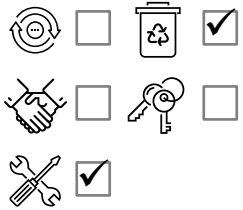
Type of technology: Digital | Physical | Biological

Digital twin and machine-to-machine (M2M) communication also enable circular business models, in addition to a solid infrastructure

	Technology	Description and circular examples	Illustrative CE value driver	Business model relevance
Improving	**Digital twin** 	Is 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	
Improving	**Machine-to-machine (M2M) communication** 	Connects data, analytics and machines based on sensors and actuators *Example: Hello Tractor has a "Smart Tractor" sharing platform that connects tractor owners with farmers. The system links SMS message requests with software that identifies nearby tractors with the required usability and functionality*	Increasing the usable lifecycle of products by providing real-time information	
	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 or Fog Computing, Cloud, Scalable API should be considered and technological advancements followed to keep infrastructure up-to date		

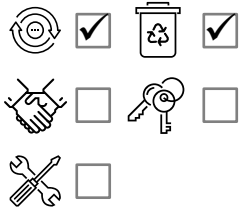
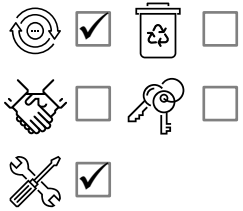
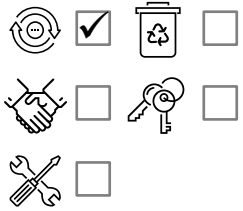
Type of technology: Digital | Physical | Biological

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

	Technology	Description and circular examples	Illustrative CE value driver	Business model relevance
Scale-up/aging	**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/aging	**UV/IR/NIR/NMR spectroscopy** 	Uses different spectrums of electromagnetic radiation to analyze 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	

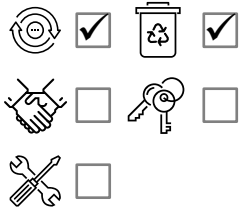
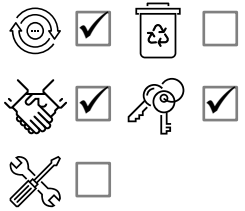
Type of technology: Digital | Physical | Biological

New materials, nanotechnology and energy harvesting are further physical technologies

	Technology	Description and circular examples	Illustrative CE value driver	Business model relevance
Improving	**New materials** 	Advances in material sciences have led to development of polymers or 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 maritime 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 environment 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	

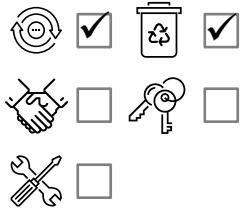
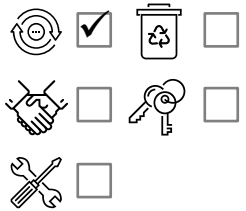
Type of technology: Digital | Physical | Biological

Carbon capture and energy storage are also physical technologies supporting circular value

	Technology	Description and circular examples	Illustrative CE value driver	Business model relevance
Improving	**Carbon capture** 	Captures waste carbon dioxide from large point sources, transports it to a storage site and deposits it where it will not enter the atmosphere *Example: Graviky, a spinoff from the Massachusetts Institute of Technology, recycles carbon dioxide emissions to produce ink*	Reduces emissions in the atmosphere	
Emerging	**Energy storage** 	Prolongs the life of batteries, increases their storage capacity, or replaces existing chemical-based raw material with organic substances *Example: Iberdrola, has built the largest pumped-hydro storage plant in Europe, where two reservoirs with over 500 meters of altitude difference are used to produce electricity during peak consumption times*	Enables increased use of renewable energy	

Type of technology: Digital | Physical | Biological

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

	Technology	Description and circular examples	Illustrative CE value driver	Business model relevance
Improving	**Bio energy** 	Is 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 petrol-based materials and cascading of biomass	
Emerging	**Bio-based materials** 	Composed out of biopolymers and other natural-fiber created partially or wholly by using pant feedstock *Example: Mazda uses bioplastic in the interior of its cars and also launched it that as scratch and weather resistant material used as coating for cars*	Substitution of petrol-based materials through renewable	

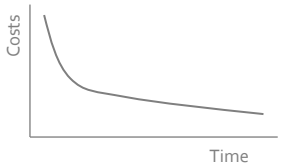
Type of technology: Digital | Physical | Biological

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

Price comparability

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

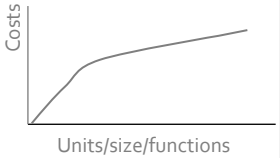
- By 2020, cost of IoT sensors will have decreased by 70% from 2004[1]
- Price for Robot arms dropped about 25% between 2014 and 2017 and will further decrease by 22% by 2025[2]



Scope dependency

Costs for implementation are highly dependent on the scope

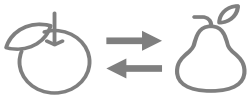
- Depending on the scope of technology application (size of operation facilities, complexity of products, number of processes), the required units or the size of equipment will vary (e.g. robot arms: €20k-350k[2])



Comparability

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

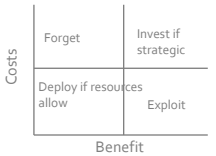
- Prices for technologies are only comparable if they deliver the same function
- Compare benefit of technologies to the company for prioritisation



Business case

Whether the price for a technology implementation makes economic sense or not, depends on the achievable revenues or 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 innovative materials is **not clear upon first application** and regulations are missing – e.g. 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 or 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]

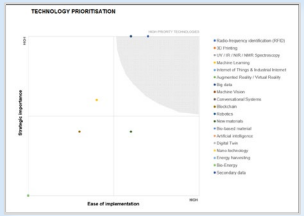
Source: 1: The Guardian, 2: OECD/Alliance ; 3: Autodesk, 4: Sustainablebrands.com, 5: Openaccessgovernment.org, 6: IMB, 7: IT governance, 8: International bar association

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

1

Technology maturity assessment

Tool for assessing your company's maturity in the technologies enabling circular business models and prioritizing those for development



Estimated working time: 20 min

Which technologies can support?
Business model canvas

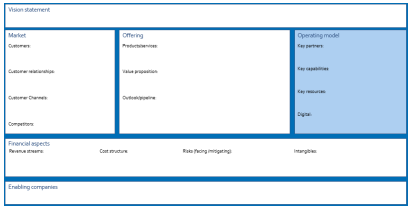
Key questions

1. What technologies can be used to support the initiatives?
2. What are the key actions required to implement these technologies?
3. Who are the key partners you need to collaborate with?

Business model canvas

Based on the information learnt in this chapter, fill in the following parts of the business model canvas:

- **Operating model** – reflect on key partners and digital technologies needed to operate



5 How to design the transformation journey?

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

CHAPTER SUMMARY

How to design the transformation journey?

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

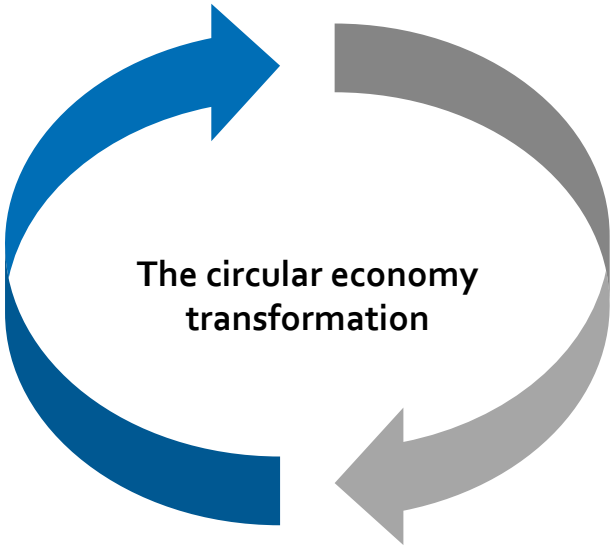
Roadmap development

- The transformation journey required to leverage the circular advantage has two key elements: I) Envision and plan and II) Deliver and adapt.
- 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
- Companies often face barriers along the transformation journey, typically related to (a) organization & 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

Organizations should start addressing 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

Key element no. 1: "Envision and plan"

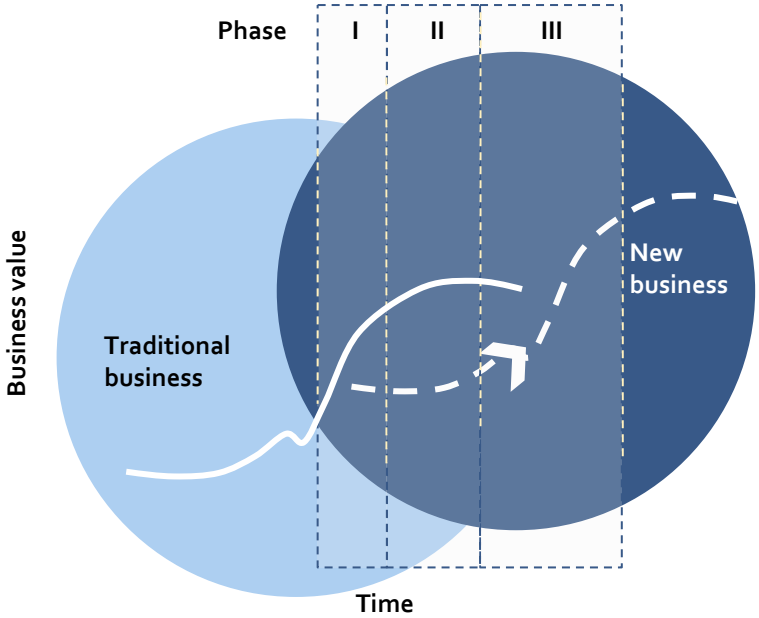
Key activities

1 Why: Define vision for the 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

Key element no. 2: "Define 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

Old business model

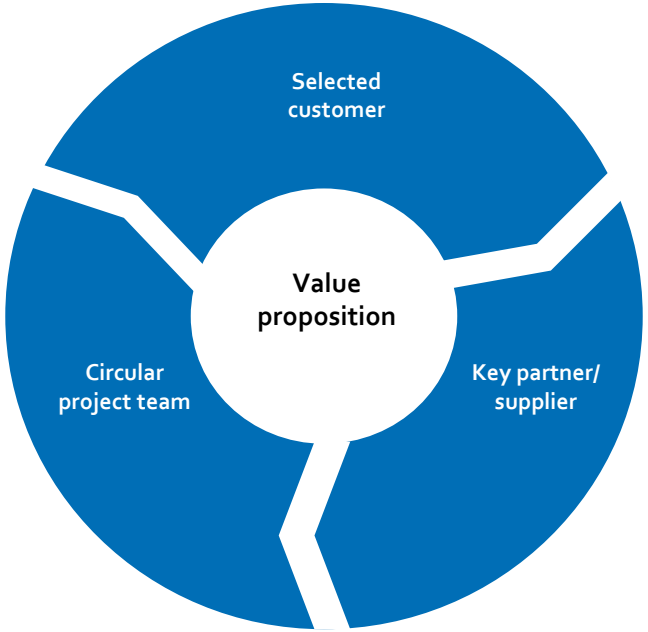
New business model

Time

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



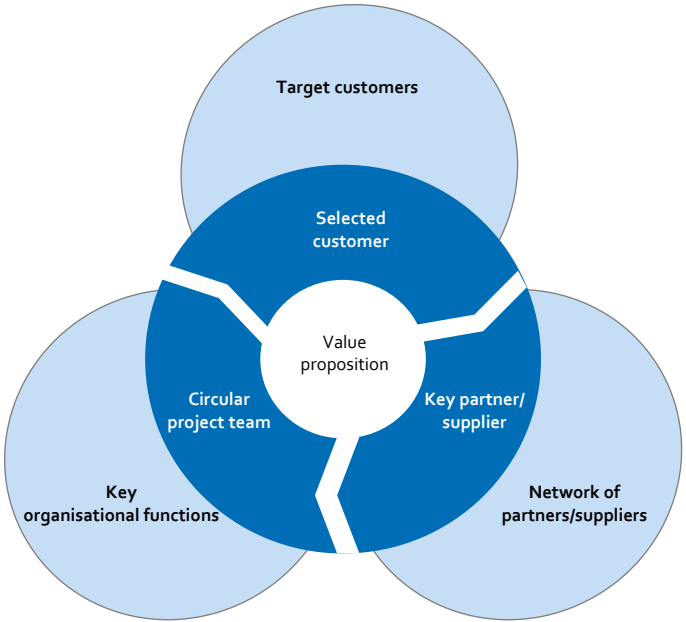
Description

- 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



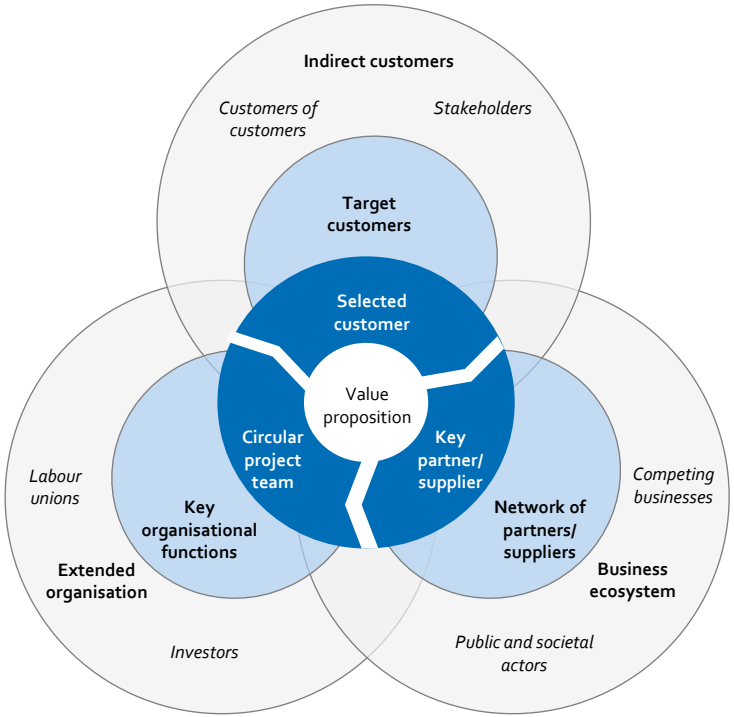
Description

- 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



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

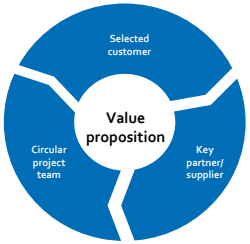
- Michelin leverages the overall ecosystem by drawing on
  - Strategic partners to jointly develop solutions to ensure credibility through a network of recognised partners (e.g. insurance company, telecom provider)
  - Business partners to benefit from their technical or commercial expertise to extend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

I. Explore & shape

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

Illustration of company state

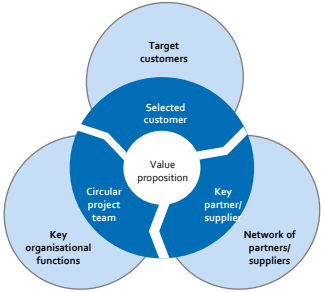


Key characteristics

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

II. Attract & win

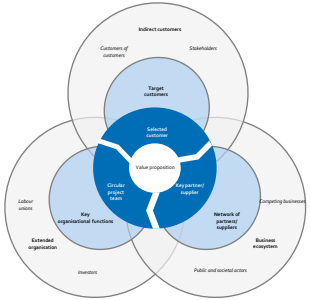
Develop processes and partnerships and pilot new solution to convey benefits



- 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



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

Time

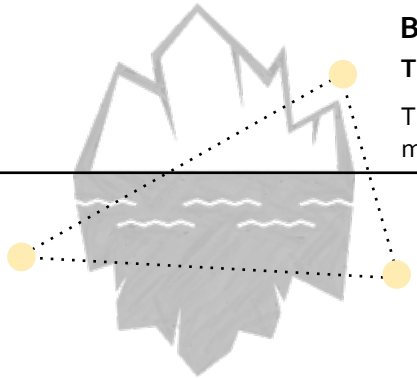
Companies typically face several barriers during their circular transformation journey

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** financiers and businesses must **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 circular 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

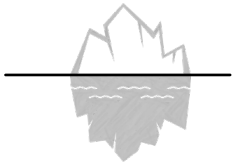
"The way we do things around here"

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

Illustrative



		Culture		
		Values	**Mindset**	**Behaviours**
Company-level		• Sustainability • Customer value creation • Collaboration and 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 lifecycle in design
	Sourcing & procurement		• Recycled, reused or renewable material should be used where possible	• Explore new suppliers for material source
	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 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 lifecycle	Internal → Collaborative Processes for continuous engagement along product lifecycle 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 or product family to optimise the value delivered to a customer

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

4. Manage culture change with dedicated programme

Case study: Component manufacturer

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

5. Understand full circular advantage from collaborative ecosystem

Illustrative

Bundled offerings
Make e.g. sharing concepts more attractive for customers

Ecosystem design
- Partner with companies offering complementary services or products (e.g. insurance for shared products)

Opportunity
- Enables to capture value from underutilised capacity of products by addressing potential customer pain points upfront

Challenges
- Identifying relevant product or service combinations
- Potential cannibalisation of individual product or service sales

Business model relevance

Circular inputs	Sharing platform	Product use extension	Resource recovery	Product as a service
☐	✓	✓	☐	✓

Joint delivery of services
Increases service spectrum to deliver product use extension

Ecosystem design
- Partner with companies delivering use phase services and technology companies enhancing own product e.g. for remote control

Opportunity
- Enables to operate business models that require capabilities currently not available at a company (e.g. onsite maintenance and repair service

Challenges
- Distribution of captured value among partners

Business model relevance

Circular inputs	Sharing platform	Product use extension	Resource recovery	Product as a service
☐	✓	✓	☐	✓

Value chain reconfiguration
Improves collection of material for reuse and recycling

Ecosystem design
- Partner with companies throughout the whole value chain jointly working on resource recovery

Opportunity
- Enable high quality recycling of large (mostly) uniform material that is currently not recoverable in a linear value chain

Challenges
- Exchange of information on material or material composition
- Work towards unification of input material (as required)
- Purity of recovered material in collection

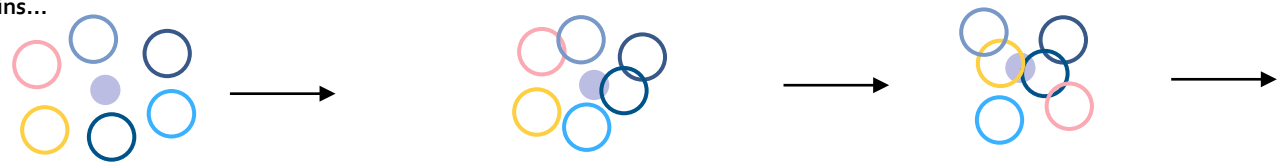
Business model relevance

Circular inputs	Sharing platform	Product use extension	Resource recovery	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

From industry-specific value chains…



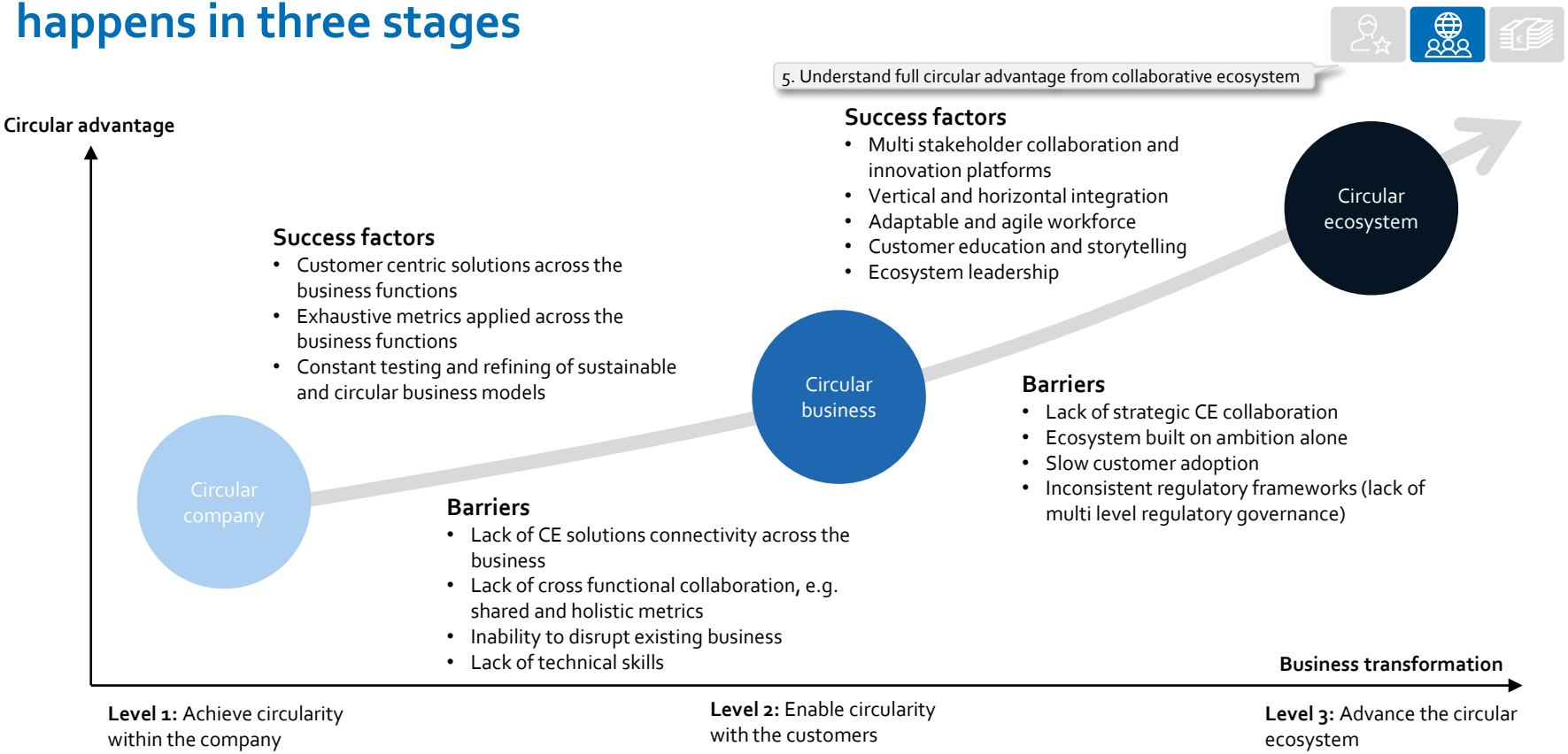
…to cross-industry value networks

Company Partners

	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

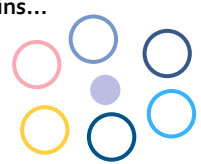
The transformation to a circular ecosystem typically happens in three stages



Ecosystem partners can help in bridging internal capability gaps

6. Identify partners to develop ecosystem

From industry-specific value chains…



…to cross-industry value networks

Company Partners

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

Norsk Gjenvinning, Veolia, SSAB, DHL, Sortera Recycling

Technology providers

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

SICK Sensor Intelligence., ramentor, Power BI, tableau

Circular economy thought-leaders

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

Nordic Innovation, SITRA

Financiers

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

DNB, Taaleri, Swedbank

Public and societal actors

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

BUSINESS FINLAND, Innovasjon Norge

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.

The ecosystem actors generate value in different parts of the value chain

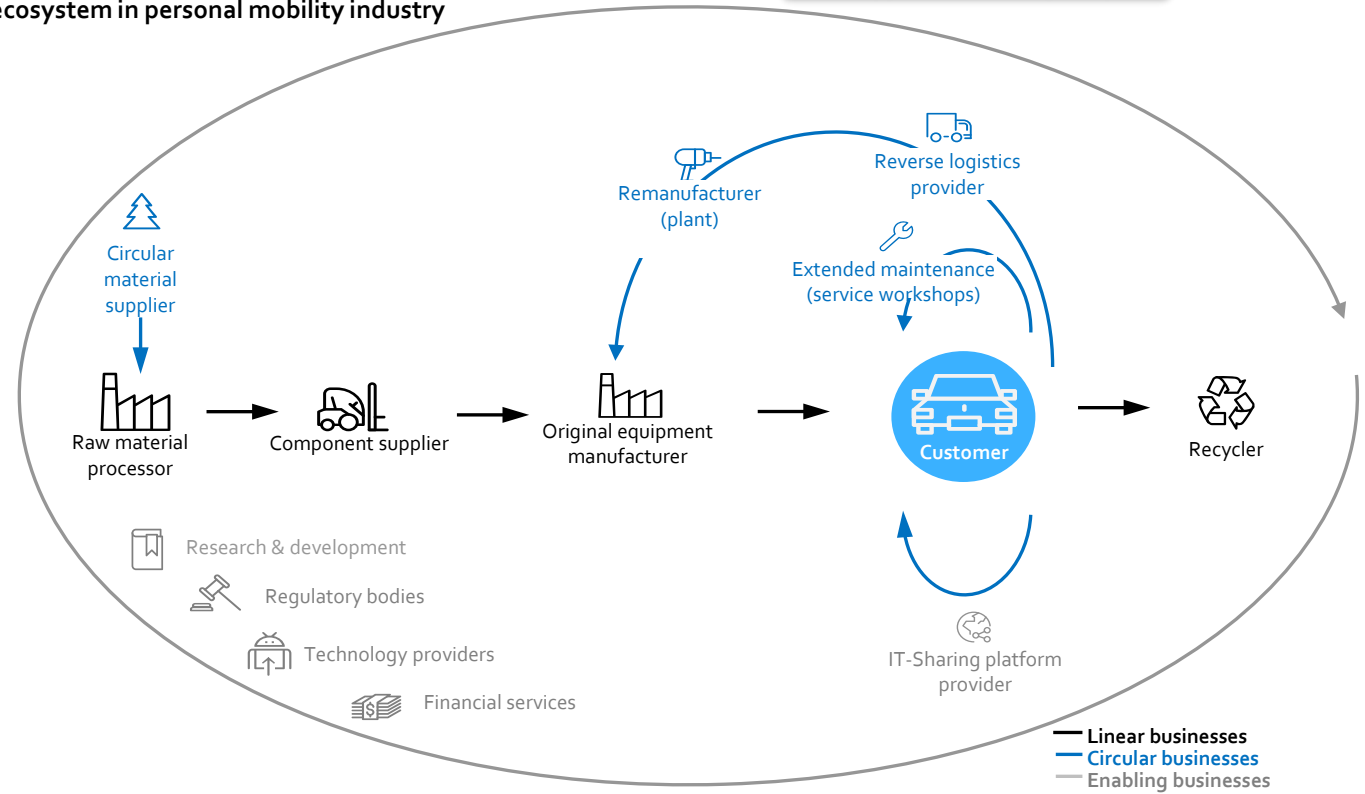
6. Identify partners to develop ecosystem

Illustrative example from ecosystem in personal mobility industry

Linear businesses

New
Circular businesses

New
Enabling businesses



New circular business models redefine the business ecosystems

6. Identify partners to develop ecosystem

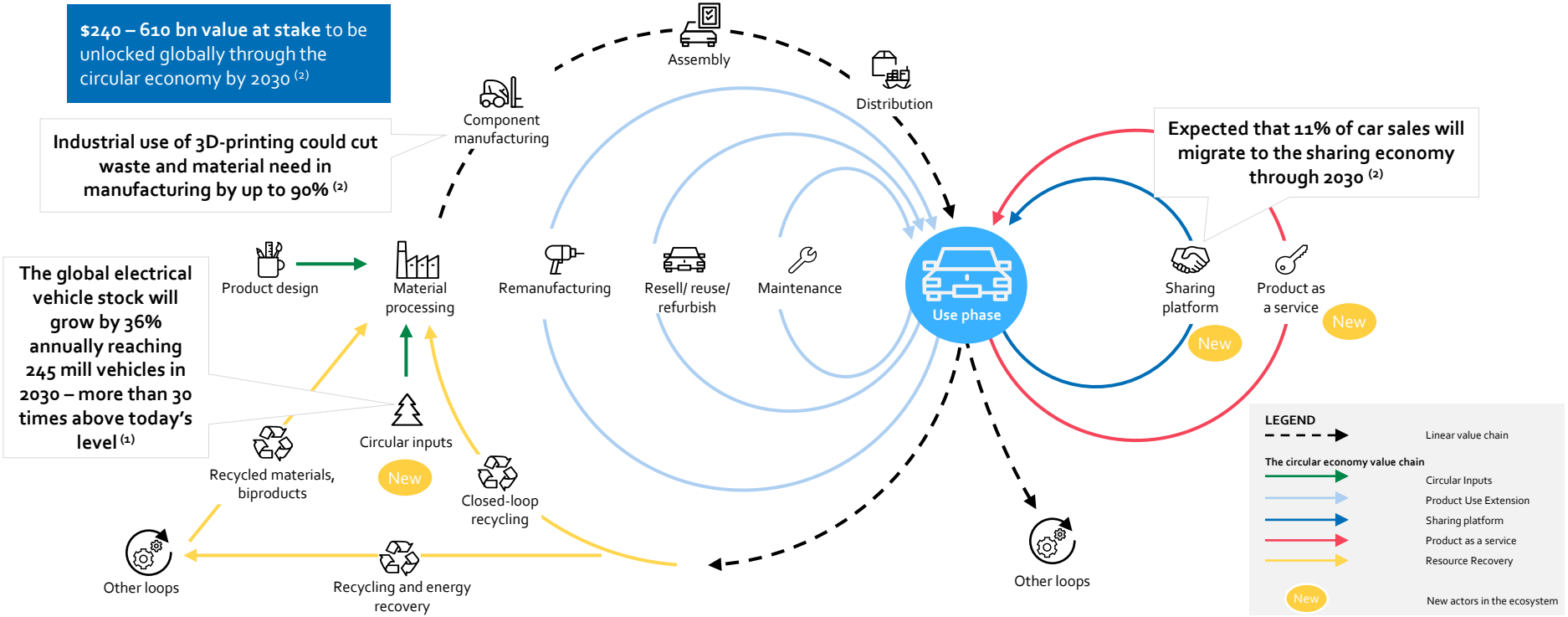
Illustrative example from sub-models and value in personal mobility industry

$240 – 610 bn value at stake to be unlocked globally through the circular economy by 2030 (2)

Industrial use of 3D-printing could cut waste and material need in manufacturing by up to 90% (2)

The global electrical vehicle stock will grow by 36% annually reaching 245 mill vehicles in 2030 – more than 30 times above today's level (1)

Expected that 11% of car sales will migrate to the sharing economy through 2030 (2)



Source: (1) IEA 2020, Global EV Outlook 2020, Sustainable development Scenario, (2) Circular Economy Handbook - Appendix 2 for more details

Regulations around the circular economy are evolving but there are still regulatory barriers present

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

Type of regulatory barrier	Business impact	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 or 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 circular economy benefit

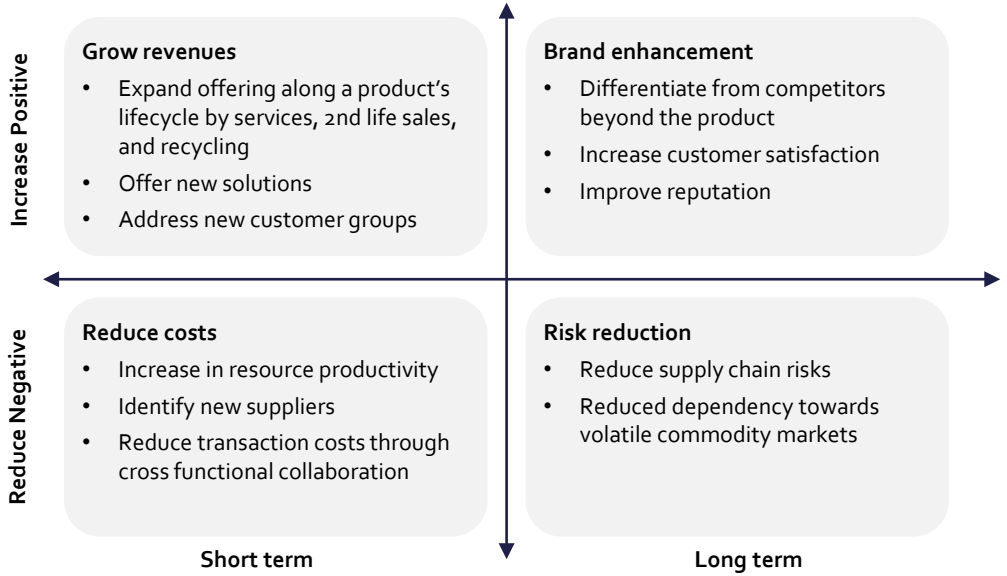
Common situation in business

"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 circular economy can outweigh rejections



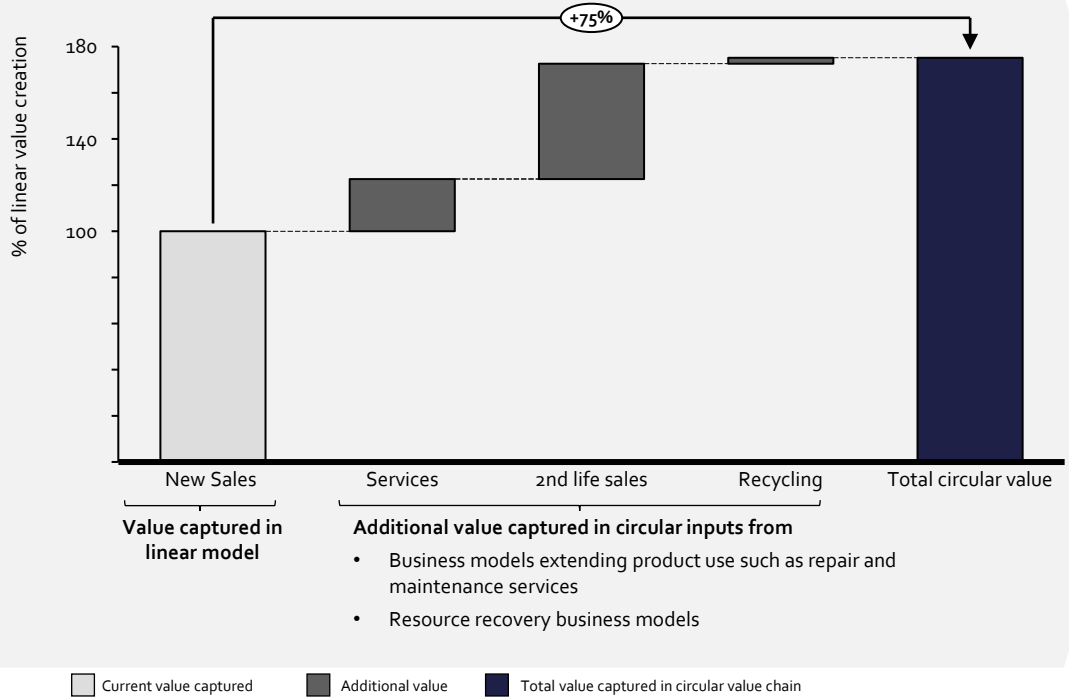
Did you know? On the Circular Economy site, there is a **Value case tool**, with which you can calculate a high-level business case, including investment need, for the circular economy business models for your company.

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

8. Holistically assess circular economy benefit

Illustrative

Illustrative financial benefits



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

- Services 22%
- 2nd Life sales 50%
- Recycling 3%

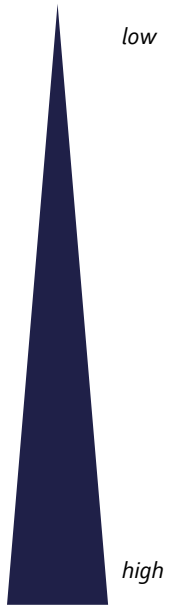
Based on estimates for automatic and micro dive

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

9. Understand business model specific funding requirements

Funding requirements	Applicability for business models	Financial implications
Incremental investments to extend offering portfolio	Circular Inputs Product Use Extension Resource Recovery	• 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

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

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)

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

Mitigation strategies

- 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
- Collect deposit to 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
- 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.

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

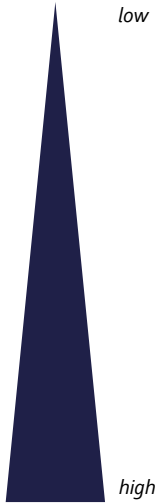
Did you know? On the Circular Economy site, there is a tool called **Funding requirement analysis**, which helps you to reflect on your funding needs and sources.

Besides bank loans, other funding sources and instruments can be explored for circular economy 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** **Debt finance** (Green bonds)	• Only applicable for larger and mature circular businesses that meet the scale and requirements of the capital markets
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 Nordic banks and private funding institutions are open for circular and sustainable businesses

12.Identify funding partner and instrument

Banks

Most common SME finance source

- **Danske Bank** has no specific circular economy focus but general sustainability and carbon reduction strategy
- **DNB** has principal target to integrate sustainability considerations in operations and a Sustainable Business Framework that governs sustainable lending activities
- **Ekobanken** grants loans to operations that create social, environmental or cultural added value
- **Nordea** has mission to enable transition to a sustainable future. Addresses UN's SDGs and e.g. has experience with product use extension from customers
- **OP Financial Group** has green bond framework and e.g. supports DriveNow car sharing model in Helsinki region
- **Arion Banki** is focusing on financing projects on sustainable development and green infrastructure, and evaluates loan portfolio according to green criteria

Other private funding institutions

- **Grannenfelt Finance** – financial solutions provider , drawing on different sorts of funding solutions (equity, debt, EU or government funding)
- **Loudspring** accelerator for companies that aim to save natural resources – generally in early stage
- **Taaleri** – financing company operating the world's first Private Equity CE Fund
- **Tesi** – venture capital and private equity company, has the circular economy as a new focus

Public funding institutions

Involving supply chain partners in financing discussions (e.g. through signed contracts) can support the funding process

Source: Company and organization websites

In addition, public funding sources can be approached to secure further funding

12.Identify funding partner and instrument

Banks Most common SME finance source

Other private funding institutions

Public funding institutions

- **The European Investment Bank and European Commission funds initiatives via the European Fund for Strategic Investments (EFSI),** provides guarantees via InnovFin and research support under Horizon Europe
- **C-VoUCHER** is an EU circularity innovation program led by FundingBox aimed at supporting 60+ SMEs in their transition to circular business models through equity-free funding and acceleration services
- **Finnish ministry of economic affairs,** e.g. provides €2m funding for CE initiatives in 2019
- **Business Finland** offers funding programs for SMEs, e.g. aiming to expand internationally
- **CLIC Innovation** – open innovation cluster with mission to facilitate creation of breakthrough solutions, e.g. in CE

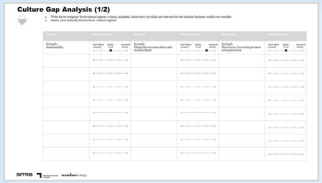
- **Erhvervsstyrelsen** works to create growth and development opportunities in Denmark, e.g. CSR
- **Vinnova** is Sweden's innovation agency that fund research and innovation projects, e.g. CE
- **RE:Source** is a strategic, Swedish innovation program focusing on developing circular, resource efficient material flows. Has financed 150 projects since 2016
- **NMI (Innovation Center Iceland)** encourages innovation and promotes the advancement of new ideas in the Icelandic economy, e.g. through idea development and funding
- **Rannis** supports research, innovation, education and culture in Iceland. E.g. administers competitive funds
- **Innovasjon Norge** supports companies in developing their competitive advantage and enhance innovation

Involving supply chain partners in financing discussions (e.g. through signed contracts) can support the funding process

Source: Company and organization websites

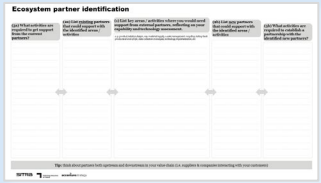
Various tools will help you get started with your circular transformation journey

1 **Culture gap analysis**
Tool for analyzing how circular your current company culture is and outlining activities to bridge identified culture gaps



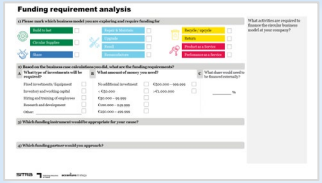
Estimated working time: 15 min

2 **Ecosystem partner identification**
Tool for identifying external partners that can help in bridging internal capability and technology gaps



Estimated working time: 15 min

3 **Funding requirement analysis**
Tool for reflecting on funding requirements of your selected circular business model



Estimated working time: 15 min

4 **Roadmap development**
Tool for planning your circular transformation journey, including list of activities and key milestones

Estimated working time: 30-45 min

How to start the transformation journey?
Business model canvas

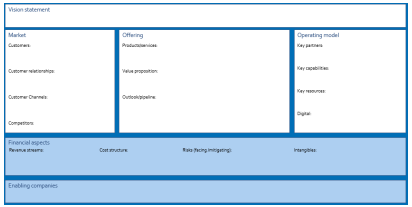
Key questions

1. What are the key actions required to make the opportunities happen?
2. Who are the key partners you need to collaborate with?
3. What barriers might you encounter when implementing the initiatives? How can you mitigate them?

Business model canvas

Based on the information learnt in this chapter, fill in the following parts of the business model canvas:

- **Financial aspects** – make a high-level estimate on revenues, costs, and required investments
- **Enabling companies** – list companies that can support the development of your circular business model, such as financiers and technology providers



6 Industry deep-dives

Current state analysis and circular opportunities for machinery & equipment, maritime, energy, transportation and construction

CHAPTER SUMMARY

Industry deep-dives

This chapter will help you to:

- Gain in-depth knowledge of the current state and 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

- Machinery & equipment, maritime, energy, transportation and construction are important ecosystems within the Nordic manufacturing industry, representing 60% of Nordic manufacturing exports
- Therefore, these sub-sectors play a key role in driving wider adoption of circular business models across the Nordic business landscape
- This section takes a deep-dive into the current state of these five sub-sectors, looking at inefficiencies in the current value chains and showcasing circular economy examples
- Overall, inefficiencies occur in all parts of the linear value chains. Still, compelling circular business model examples from Nordic and international companies exist, and inspire others for action

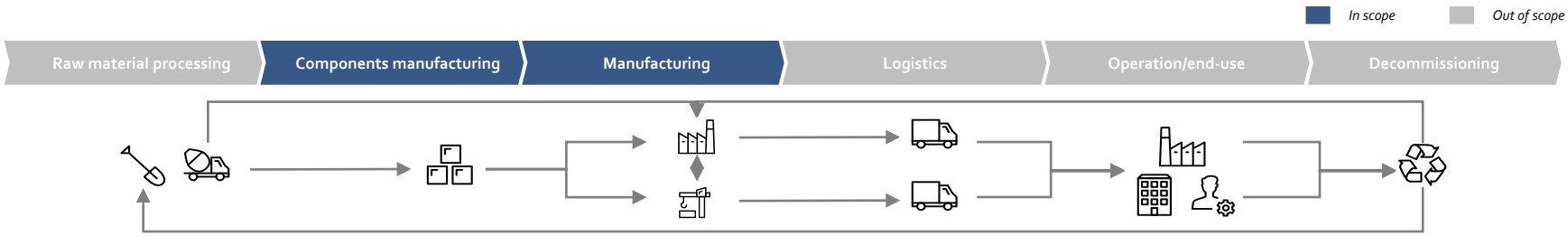
The playbook takes a deep dive into five important ecosystems within the Nordic manufacturing industry

Machinery & equipment	Maritime	Energy	Transportation	Construction
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	Manufacture of ship parts and maritime equipment, such as hull, propulsion and power engines, other systems and solutions and interior equipment	Manufacture of electrical equipment, such as batteries, accumulators, wiring and wiring devices, electric lighting equipment, transformers and electricity control apparatus	Manufacture of motor vehicles, trailers and semi-trailers, and their parts and equipment	Manufacture of buildings and their materials and components

Machinery & equipment

Current state analysis and circular opportunities

Currently, the machinery & equipment value chain is focused on building efficient, long-lasting products



	Raw material processing	Components manufacturing	Manufacturing	Logistics	Operation/end-use	Decommissioning
EXAMPLE ACTORS	SSAB, Hydro, outokumpu	Componenta, Stala Tube, AQ, Nordic Aluminium	Kongsberg, KONE, ABB, Cargotec, Marel, ebmpapst, Konecranes	Havator, Wallenius Wilhelmsen, ILS, Jánhunen	YIT, Hascan, Vattenfall, Södra, fortum, Skanska	Delete, Purkupha, NG
KEY PRODUCTS AND SERVICES	Production of raw materials including • Steel • Iron • Aluminium alloy	Manufacturing components, such as • Simple metal components that mainly include 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 use 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 the circular economy initiatives pursued by some Nordic companies in the industry

However, inefficiencies occur in all parts of the machinery & equipment value chain

Inefficiency	Description of current state
UNSUSTAINABLE MATERIALS	Most input materials are recyclable and durable (e.g. steel) and the use of recycled material is common. Use of sustainable indirect materials, such as renewable energy is limited, and there are currently large investments in production sites and logistics networks to optimize energy consumption during production, product operation and end-use
UNDERUTILISED CAPACITIES	Industrial machinery is often not utilized on optimal capacity levels even if most machinery and equipment are customized to fully fit customer needs
PREMATURE PRODUCT LIVES	Products are built to last for long lifecycles, typically more than 10 years, but they are not necessarily designed for reparability or upgradeability. Many companies still acknowledge a large potential in enhancing services like repair, maintenance and upgrade services as these are not fully exploited today, for example through predictive and condition-based maintenance
WASTED END-OF-LIFE VALUE	Products and equipment are designed for long lifecycles and are often not designed with a focus on ease of dismantling and recycling. Many companies are showing a large interest for take-back schemes for their products, but few companies have managed to do this successfully
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

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

To address these inefficiencies, machinery & equipment companies should explore the five circular business models

Reform use of resources

CIRCULAR INPUTS

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

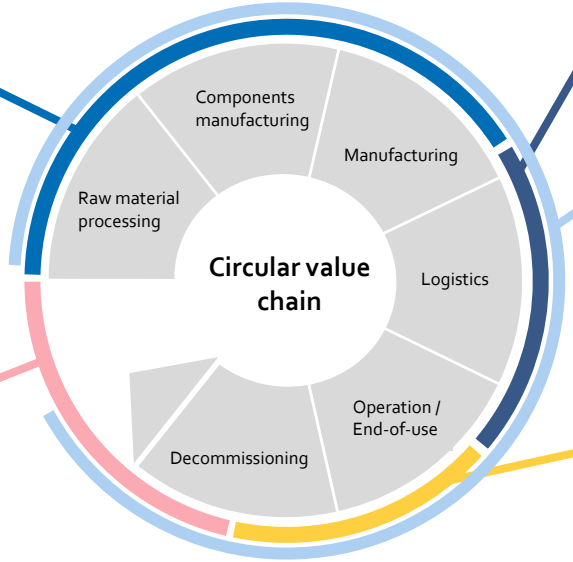
Circular supplies – Use recyclable materials in production, e.g. renewable and bio-based materials, chemicals & energy to increase recovery rates

Recover value in waste

RESOURCE RECOVERY

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 USE 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

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

Business model	*Sub-model*
Circular Inputs	Build to last
	Circular supplies
Sharing Platform	Share
Product as a Service	Product as a service
	Performance as a service
Product Use Extension	Repair & Maintain
	Upgrade
	Resell
	Remanufacture
Resource Recovery	Recycle/upcycle
	Return

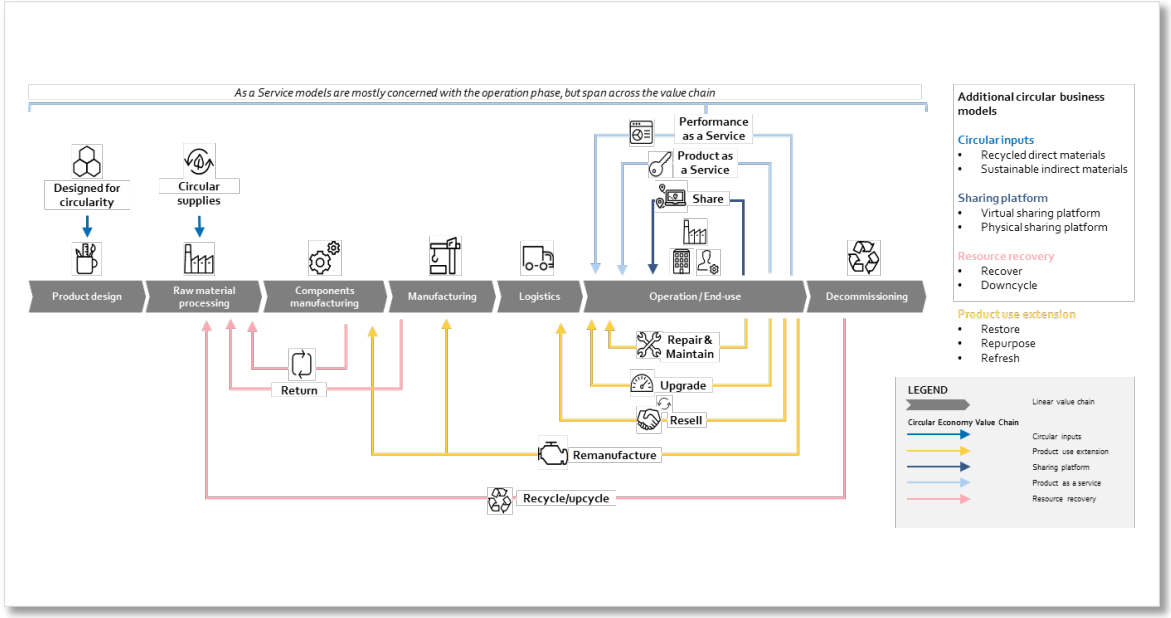


Figure: Circular business sub-models in the linear value chain

Source: Accenture, Appendix 2 for more details

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

Business model	*Sub-model*	*Examples*
Circular Inputs	Build to last	Metso:Outotec — The Metso Outotec cPlant is a modular flotation plant that offers fast, effective and affordable solutions for small mine sites or sites requiring extra capacity. The flotation plant is based on pre-fabricated and functionally tested modules inside container-sized steel frames that can be easily transported and installed, and quickly connected to the process.
	Circular supplies	
Sharing Platform	Share	
Product as a Service	Product as a service	Atlas Copco — Atlas Copco's nitrogen generator has a modular design based on the customer's specified flow, purity and pressure figures. If the customer requires extra capacity at a certain point, modules can be easily added to the existing nitrogen generator. The nitrogen generators can be used in parallel to achieve the most cost-efficient solution.
	Performance as a service	
Product Use Extension	Repair & Maintain	
	Upgrade	
	Resell	
	Remanufacture	
Resource Recovery	Recycle/upcycle	
	Return	

Source: Company websites

Sharing platforms increase utilisation rates and maximise value contribution of products

Business model	*Sub-model*
Circular Inputs	Build to last
	Circular supplies
Sharing Platform	Share
Product as a Service	Product as a service
	Performance as a service
Product Use Extension	Repair & Maintain
	Upgrade
	Resell
	Remanufacture
Resource Recovery	Recycle/upcycle
	Return

Examples

EquipmentShare

EquipmentShare is a construction machinery marketplace, including equipment such as forklifts, mobile generators and drill rigs. The rental price depends on the equipment weight, and the platform takes a cut of every transaction that occurs on the marketplace.

EquipmentShare also offers software that connects the machines and provides insight about how the equipment operates to increase utilization, productivity and efficiency on the jobsite.

eRENT

eRent is a Finnish start-up company that offers a digital platform for companies where machines, devices and other goods can be shared and tracked.

eRent aims to improve the utilization rate of equipment and eRent's main clients are equipment rental agencies, construction firms and other industrial companies from all different sectors.

Source: Company websites

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

Business model	*Sub-model*
Circular Inputs	Build to last
	Circular supplies
Sharing Platform	Share
Product as a Service	Product as a service
	Performance as a service
Product Use Extension	Repair & Maintain
	Upgrade
	Resell
	Remanufacture
Resource Recovery	Recycle/upcycle
	Return

Examples

AMECO

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

Metso:Outotec

As part of Metso Outotec's lifecycle services, Metso Outotec offers a Cost per Ton Payment Plan opportunity. If choosing this, customers 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, labor and any other needed 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 customer and it includes asset performance management for continuous equipment monitoring and diagnostics to maximize equipment availability and reliability.

1 Product-as-a-Service
Source: Company website

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

Business model	*Sub-model*	*Examples*
Circular Inputs	Build to last	
	Circular supplies	
Sharing Platform	Share	
Product as a Service	Product as a service	
	Performance as a service	
Product Use Extension	Repair & Maintain	
	Upgrade	
	Resell	
	Remanufacture	
Resource Recovery	Recycle/upcycle	
	Return	

RAMIRENT

Ramirent conducts repair and maintenance of all their machines and are starting exploring telematics and analytics to advance these services. They are also reselling old equipment to second-hand markets and conducts remanufacturing to extend the lifetime of the equipment.

SRH

SR-Harvesting buys old Valtra and Valmet tractors from both Finland and abroad. The company disassembles, cleans, repairs and sells any parts that can be repaired, and recycles the rest of the material. The repaired parts cost 55% of new similar parts and have a 6-month warranty.

CAT Reman

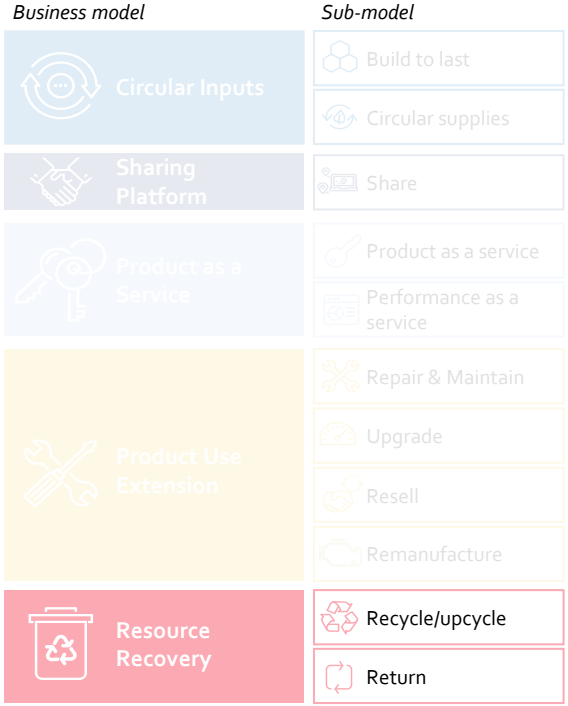
The Cat Reman program recovers materials through differentiated technology and employs environmentally sustainable practices to restore worn components to good-as-new condition. Remanufactured products are sold at a lower price with a like-new warranty. With the program, Caterpillar recycles 134 million lbs annually, and can preserve ~85% of original energy "value add".

PONSSE

Ponsse Reman offers a quick, inexpensive and eco-friendly way of replacing damaged spare parts. Reman parts is a service developed by Ponsse and is based on recycling and reconditioning used parts. The customers receive a credit for the returned part when they simultaneously buy a Reman part.

Source: Company websites

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



Examples

ZenRobotics develops and sells waste-sorting robots that separate different materials for reuse from waste.

ZenRobotics can adapt to changing waste-management and legislation requirements, and it tackles the profitability issues of waste sorting. More precise sorting allows over 95% of waste materials arriving to waste-treatment facilities to be sorted for recycling.

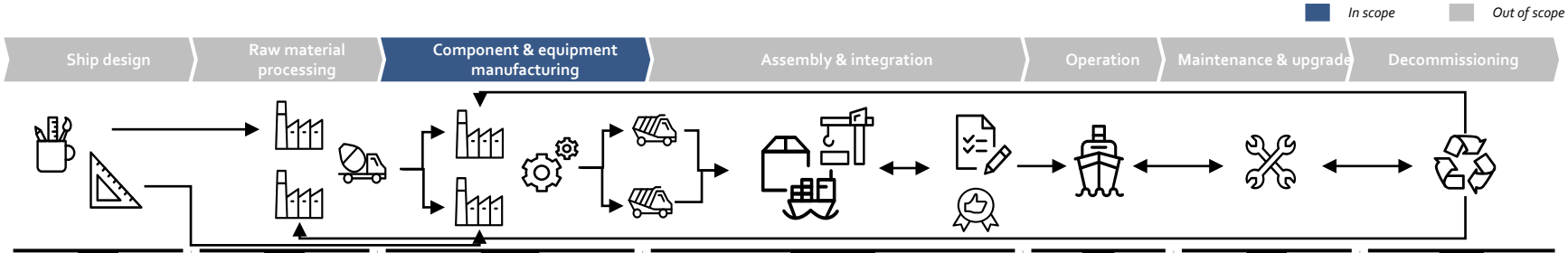
Each year, 80 000 tons of gypsum waste is generated in Norway. Even though gypsum has a recycling rate of over 90%, the majority of the waste has previously gone to landfill sites. To capture this opportunity, Norsk Gjenvinning has together with their technology partner New West Gypsum Recycling established a gypsum recycling plant. The recycled gypsum powder is a very attractive product for the gypsum producers due to the high volume and quality.

Source: Company websites

Maritime

Current state analysis and circular opportunities

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



	Ship design	Raw material processing	Component & equipment manufacturing	Assembly & integration	Operation	Maintenance & upgrade	Decommissioning
EXAMPLE ACTORS	NSK SHIP DESIGN, SSPA, FORESHIP, ENGnD	SSAB, Hydro, outokumpu	WÄRTSILÄ, Promeco, KONGSBERG, ABB, MOBIMAR	HELSINKI SHIPYARD, KLEVEN, KREFER, ULSTEIN, MOEN	Wallenius Wilhelmsen, Finnlines, CONTAINERSHIPS	TURKU REPAIR YARD, ULSTEIN	Delete, GRIEG GREEN, Hans Langh

KEY PRODUCTS AND SERVICES	Provides ship design, offshore engineering and construction support
	
	Services span from concept development to project management during shipbuilding
		Produces raw materials including:
		• Aluminum & 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 - applying modular design • Product use extension services (repair & maintain, upgrade and remanufacture) are increasingly common	Rental agreements – chartering	Lifecycle services – repair, refurbishment, repainting, etc.	• Recycle/upcycle • Return

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

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

Inefficiency	Description of current state
UNSUSTAINABLE MATERIALS	Most input materials in ships are recyclable and durable (e.g. steel or aluminum). On average, 96% of ship materials can be recycled or reused. Use of sustainable indirect materials is limited, and most efforts are focused on optimizing the safety and energy efficiency of the ship during its operation (e.g. improving the fuel efficiency).
UNDERUTILISED CAPACITIES	Underutilized capacities are one of the larges inefficiencies in the maritime industry. Many ships are left unused for long periods of time, have long idle times when in port or operated with limited use of available capacity, creating significant unnecessary costs and emissions. In 2020, the global container fleet idle time reached 10%. In terms of operational fit, ships are typically custom-built, while for maritime equipment both standardization and customization are used.
PREMATURE PRODUCT LIVES	Ships are built to last for long lifecycles, and a typical life of a ship is 20-30 years. However, ships can be scrapped prematurely due to overcapacity in the market. Ship operators are increasingly interested in refurbishment and upgrade projects to revitalize their fleet at the end of lifetime, but the cost efficiency of these upgrades is often a blocker. Non-standardized equipment and components make remanufacturing of ships challenging.
WASTED END-OF-LIFE VALUE	The ships are dismantled and recycled at end of life due to revenue gained from selling the scrapped steel and other bulk materials. However, there are some 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.
UNEXPLOITED CUSTOMER ENGAGEMENTS	After-sales and add-on sale efforts are limited for most maritime industry players, but original equipment manufacturers are now starting to establish stronger customer engagement relationships with the ship owners. The companies are now expanding their service portfolio and are exploring as-a-service business models.

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

Reform use of resources

CIRCULAR INPUTS

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

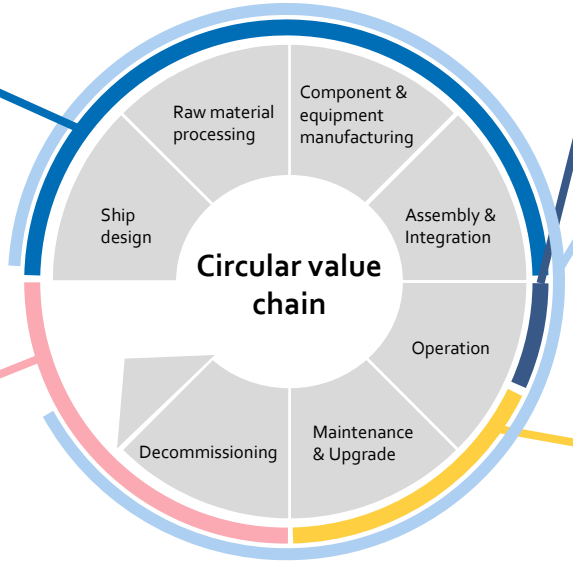
Circular supplies – Use recyclable materials in production, e.g. renewable and bio-based materials, chemicals & energy to increase recovery rates

Recover value in waste

RESOURCE RECOVERY

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 use-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 USE 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

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

Business model	*Sub-model*
Circular Inputs	Build to last
	Circular supplies
Sharing Platform	Share
Product as a Service	Product as a service
	Performance as a service
Product Use Extension	Repair & Maintain
	Upgrade
	Resell
	Remanufacture
Resource Recovery	Recycle/upcycle
	Return

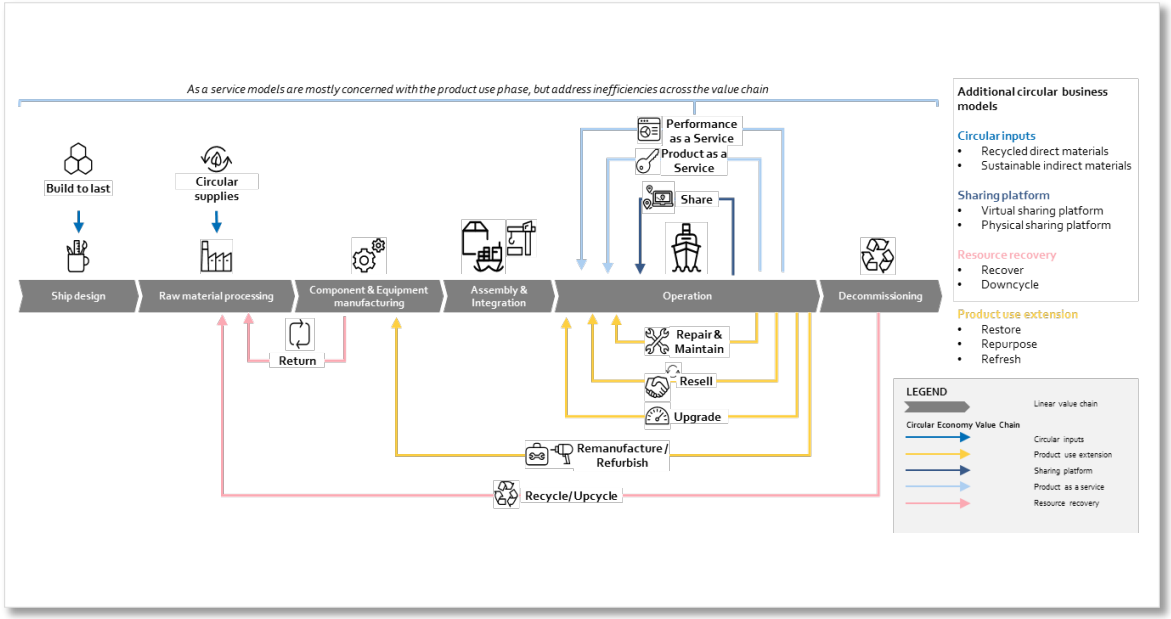
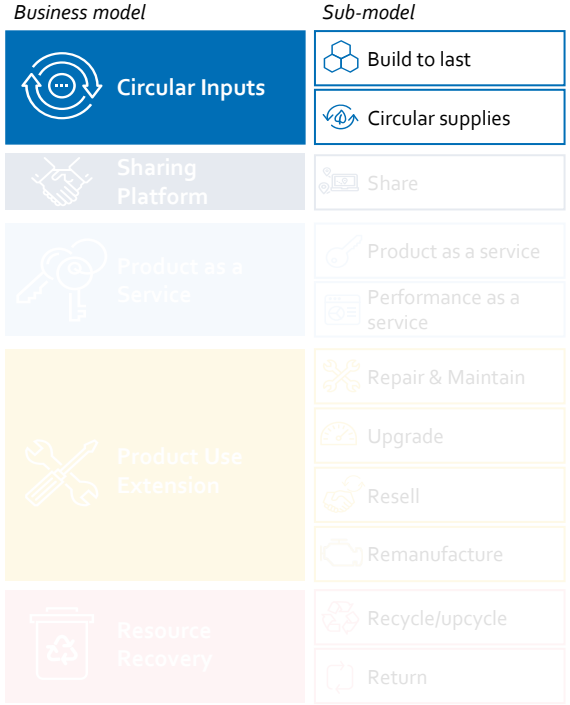


Figure: Circular business sub-models in the linear value chain

Source: Accenture, Appendix 2 for more details

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



Examples

WÄRTSILÄ

Wärtsilä applies a modular architecture in engine design to enable increased commonality and backward compatibility of parts.

This approach enables reduced product development costs, faster time-to-market, reduced maintenance time and costs and higher reusability of materials and components.

ABB

ABB has a strict approach to ensuring that all materials and components used in their products are sustainable.

The company has built sustainability into their product and technology development process, focusing on product design, material selection, and minimized material use and emission generation in manufacturing processes.

KONGSBERG

The ship, Yara Birkeland, is the world's first zero emission, autonomous container feeder. The ship will be a fully battery powered solution, prepared for autonomous and unmanned operation.

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

Business model	*Sub-model*
Circular Inputs	Build to last
	Circular supplies
Sharing Platform	**Share**
Product as a Service	Product as a service
	Performance as a service
Product Use Extension	Repair & Maintain
	Upgrade
	Resell
	Remanufacture
Resource Recovery	Recycle/upcycle
	Return

Examples

AMLA facilitates vessel sharing arrangements between member operators to maximize efficiency and reduce maritime logistics costs.

Through AMLA, member operators can increase revenue by shipping other operators' cargo or reduce their chartering costs by taking space on a fellow member's vessel.

The platform allows members to access available shippings up to a week ahead and view real time information on estimated cost and CO_2 savings.

Blockshipping has created the Global Shared Container Platform (GSCP), which aims to be the first real-time registry of the world's approximately 27 million shipping containers and a joint platform for all players in the industry for container sharing.

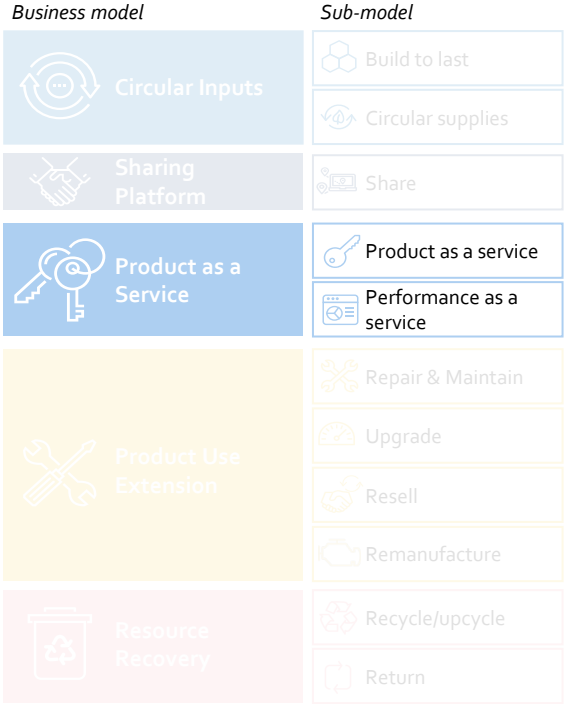
The platform aims to reduce the amount of empty containers, which is a significant issue in the shipping industry.

The platform is powered with blockchain and sensor technology and thus allows performing a wide range of transactions efficiently, such as container sharing.

According to Blockshipping, the platform has potential to reduce costs for the global shipping industry by $5.7 bn and reduce global CO_2 emissions by more than 4.6 million tons every year.

Source: Company websites

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



Examples

KONGSBERG

The 'Power by the Hour' service agreement for vessels hands the responsibility for service planning and performance to Kongsberg instead of the ship operator.

The operator pays a fixed charge per hour of operation, per ship, and Kongsberg monitors the equipment aboard each vessel from onshore with the help of onboard sensors.

The agreement insures the operator against downtime due to equipment failure and ensures optimized equipment performance.

Kongsberg 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 optimization 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

Business model	*Sub-model*	*Examples*	
Circular Inputs	Build to last	Smedegaarden	Smedegaarden sells high-quality second-hand maritime equipment from scrapped vessels such as engines, engine parts, gearboxes, thrusters, pumps and anchors.
	Circular supplies		
Sharing Platform	Share	ABB	Condition based maintenance service predicts equipment failure modes and risks related to potential failures and provides advice on when to perform repair and maintenance actions based on actual equipment condition and performance monitoring. The solution increases reliability and availability of the vessel and reduces maintenance costs.
Product as a Service	Product as a service	Schottel	Schottel offers various modernization solutions for its propulsion equipment to upgrade their performance instead of replacing them with new ones, including e.g. modernization of steering systems and interfaces and propulsion upgrades. The solutions reduce maintenance time and costs, prevent unexpected stops and downtime and reduce damage and risk of breakdown.
	Performance as a service		
Product Use Extension	Repair & Maintain	Evac	Evac is offering both retrofit and refurbishment services to upgrade the components of existing systems. Upgrades extend the lifespan of the system and allow older vessels to benefit from the latest technologies.
	Upgrade		
	Resell	Wärtsilä	Wärtsilä offers remanufacturing services for engine components, bringing worn out components back to their full functionality. The quality of remanufactured components is equal to new ones, while their price is significantly lower. Therefore, the solution substantially reduces costs of maintenance while also reducing environmental footprint through material reuse.
	Remanufacture		
Resource Recovery	Recycle/upcycle	Piikkiö Works	Piikkiö Works offers turnkey wet cell refurbishment (Wetref) for cabins, which is a complete solution for upgrading the ageing wet cells of a ship. Refurbishment extends the lifecycle of the cabins and upgrades them to meet changing customer expectations.
	Return		

Source: Company websites

Resource recovery of ship parts, materials and equipment enables both cost and environmental efficiencies

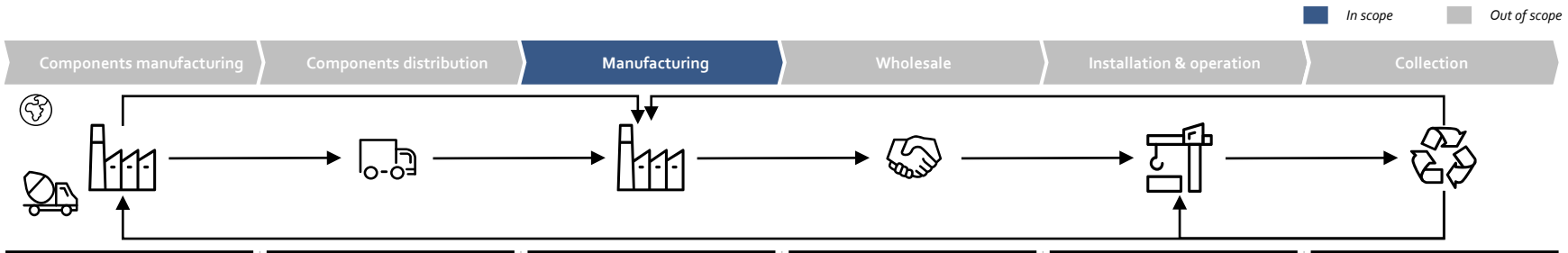
Business model	*Sub-model*	*Examples*
Circular Inputs	Build to last	WÄRTSILÄ: The material from Wärtsilä's end-of-life components is used to create recycled material. Recycled material, such as end-of-life coins and bronze propellers from propulsion equipment is used in casting new propellers, thus reducing the environmental impact of the products.
	Circular supplies	
Sharing Platform	Share	MAERSK: Cradle-to-Cradle Passport is a database listing the material composition of the main parts of the ship, enabling better recycling of materials and parts used in vessel construction. The database will cover about 95% (by weight) of the materials and updating it involves around 75 suppliers to the ship.
Product as a Service	Product as a service	
	Performance as a service	
Product Use Extension	Repair & Maintain	SEA 2 CRADLE: Sea2Cradle offers services to assist owners of marine assets with the safe and sustainable recycling of their asset. These services include the preparation of inventory of hazardous materials, brokerage, recycling facility audits, ship recycling plans and acting as owners' representative at the recycling facility during the entire recycling process. Sea2Cradle's goal is to continuously raise the bar for safe and sustainable recycling, aiming at 100% recycled materials, with zero incidents.
	Upgrade	
	Resell	
	Remanufacture	
Resource Recovery	Recycle/upcycle	KONGSBERG: Kongsberg provides a recycling service for recycling all Kongsberg Maritime products and equipment. The service is free of charge and ensures that worn equipment is recycled or disposed responsibly.
	Return	

Source: Company websites

Energy

Current state analysis and circular opportunities

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



	Components manufacturing	Components distribution	Manufacturing	Wholesale	Installation & operation	Collection
EXAMPLE ACTORS	SUMITOMO ELECTRIC, crydom, Amphenol	ARROW ELECTRONICS, INC., MOUSER ELECTRONICS	Danfoss, ABB, Schneider Electric, VACON, northvolt, VEXVE	solar, SLO, ahlsell, onninen		ABB, RENAS, L&T
KEY PRODUCTS AND 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 use 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 the circular economy initiatives pursued by some Nordic companies in the industry

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

Inefficiency	Description of current state
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. For the majority of electrical equipment companies, the use of both direct and indirect recyclable or renewable materials in production is limited.
UNDERUTILISED CAPACITIES	Capacity use of energy equipment is not always optimized, even if they are often built to fully meet customer needs and requirements through customization. This is due to both unexpected downtime on the equipment and fluctuations in customer demand where the equipment is not used.
PREMATURE PRODUCT LIVES	Electrical equipment is often replaced due to limited opportunities for upgrades and customers opting for the products with the newest technologies. Not all electrical equipment reach their technical life targets due to challenging conditions and improper care. Equipment maintenance often happens according to schedule, not need, which increases the wasting of resources.
WASTED END-OF-LIFE VALUE	Recycling of electrical equipment is very limited, as the volume and the value of recovered materials is low. It is therefore challenging to achieve volumes at scale and a cost-efficient process. Also, many products are sold outside the Nordics and Europe, making their take-back and recycling challenging due to disconnected producer responsibilities. New Nordic collaborations such as Recipo, the collective collection and recycling system for electrical and electronic equipment, have been created to mitigate some of these challenges.
UNEXPLOITED CUSTOMER ENGAGEMENTS	There are some companies working on increasing their share of revenues from both after sales and add-on sales, however, on a general basis providing outcome-oriented solutions is very rare in the industry.

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

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

Reform use of resources

CIRCULAR INPUTS

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

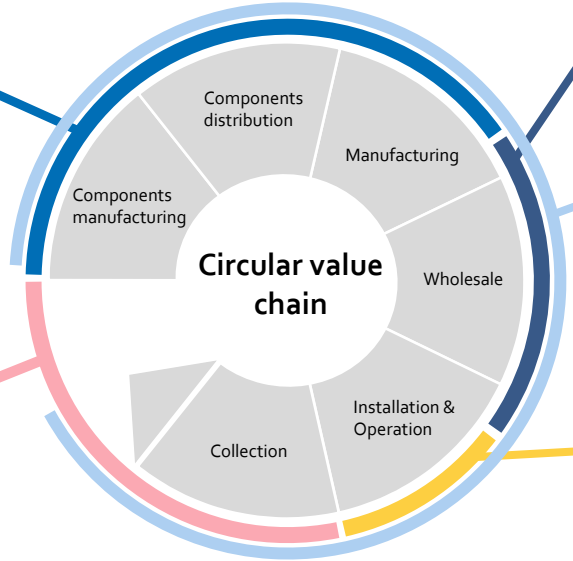
Circular supplies – Use recyclable materials in production, e.g. renewable and bio-based materials, chemicals & energy to increase recovery rates

Recover value in waste

RESOURCE RECOVERY

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 capacity

Offer outcome-oriented solutions

PRODUCT AS A SERVICE

Product as a service – Offer customers to use a product against a subscription fee or use-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

Extend lifecycles

PRODUCT USE 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 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 parts and equipment, and remarket them with lower price

Source: Accenture, Appendix 2 for more details

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

Business model	*Sub-model*
Circular Inputs	Build to last
	Circular supplies
Sharing Platform	Share
Product as a Service	Product as a service
	Performance as a service
Product Use Extension	Repair & Maintain
	Upgrade
	Resell
	Remanufacture
Resource Recovery	Recycle/upcycle
	Return

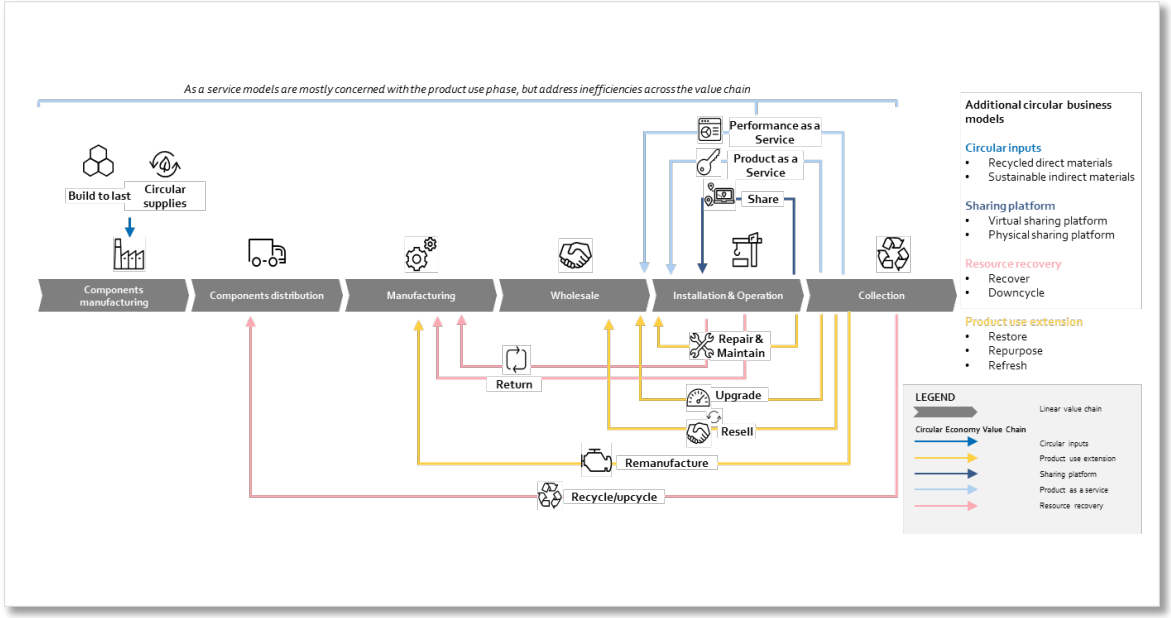


Figure: Circular business sub-models in the linear value chain

Source: Accenture, Appendix 2 for more details

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

Business model	*Sub-model*	*Examples*
Circular Inputs	Build to last	Schneider Electric initiated a program in January 2015, where they started upgrading products that had become obsolete while in storage. This means that instead of traditionally dismantling the products to raw materials and reusing the raw materials, they use as much of the old products components in new versions. The approach has been successful with product groups such as circuit breakers and wiring devices.
	Circular supplies	
Sharing Platform	Share	
Product as a Service	Product as a service	Vacon NXP System Drives have a modular design which enables customization and cost savings. The product design also means that faults are reduced to certain components and the components can be changed quickly in case of a breakdown.
	Performance as a service	
Product Use Extension	Repair & Maintain	
	Upgrade	
	Resell	
	Remanufacture	
Resource Recovery	Recycle/upcycle	
	Return	

Source: Company websites

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

Business model	*Sub-model*	*Examples*
Circular Inputs	Build to last	
	Circular supplies	
Sharing Platform	**Share**	SOLshare
Product as a Service	Product as a service	
	Performance as a service	
Product Use Extension	Repair & Maintain	
	Upgrade	
	Resell	
	Remanufacture	
Resource Recovery	Recycle/upcycle	
	Return	

SOLshare is the world's first peer-to-peer solar electricity trading platform that leverages existing solar home systems (SHS) in an off-grid context to create a bottom-up smart grid. The platform allows individuals to share their excess electricity with roughly a dozen other homes, of which some are equipped with solar panels and others not.

Source: Company websites

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

Business model	*Sub-model*
Circular Inputs	Build to last
	Circular supplies
Sharing Platform	Share
Product as a Service	Product as a service
	Performance as a service
Product Use Extension	Repair & Maintain
	Upgrade
	Resell
	Remanufacture
Resource Recovery	Recycle/upcycle
	Return

Examples

SOLNET

Solnet offers solar power systems as a service, both on a turnkey basis and through service agreements, in which the customer pays a rate for the produced electricity. Solnet's customers are primarily owners of large property portfolios.

PHILIPS

Philips has several case examples of selling light as a service. This performance-based service can be sold through several business models, such as both pay-per-lux and monthly subscriptions. These service-based models often lead to lower lifecycle costs, energy reductions and better optimization and simplicity for the end-user.

Source: Company websites

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

Business model	*Sub-model*
Circular Inputs	Build to last
	Circular supplies
Sharing Platform	Share
Product as a Service	Product as a service
	Performance as a service
Product Use Extension	Repair & Maintain
	Upgrade
	Resell
	Remanufacture
Resource Recovery	Recycle/upcycle
	Return

Examples

ABB

ABB Transformer Remanufacturing and Engineering Services reduces downtime and minimizes 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.

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 optimization and a guaranteed upgrade path.

Fischer Lighting (FISCHER LIGHTING FOR A BRIGHTER FUTURE)

Fischer Lighting extend the lifetime of used lighting fixtures by producing modular LED solutions built on existing fixtures. The solution offers all the functionality, lighting quality and energy saving technology expected from state-of-the-art LED.

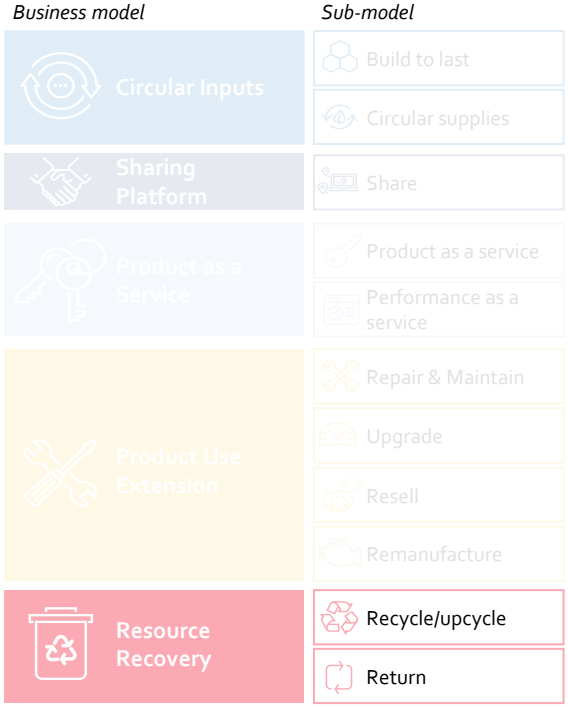
The LED solutions frequently lead to fewer disruptions in the installation phase, as it will not be necessary to rebuild or restructure ceilings. The solutions can be taken apart, eliminating the need to discard the lamp or fixture in connection with future upgrades.

Schneider Electric

The Schneider Electric Circuit Breaker Retrofit program modernizes and updates electrical distribution centers. 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



Examples

SIEMENS

The total Siemens recycling rate is 90%, which is far beyond complying with legal requirements. Siemens has its aims set even higher, by targeting for 0% waste to landfill, 100% of air emissions controlled and 6% improvement in energy efficiency.

GRUNDFOS

Grundfos has a take-back scheme for used circulators. The scheme covers the Danish home market and has been developed in cooperation with wholesalers. All major circulator wholesalers are participating in the voluntary scheme, corresponding to more than 200 wholesalers across Denmark.

Schneider Electric

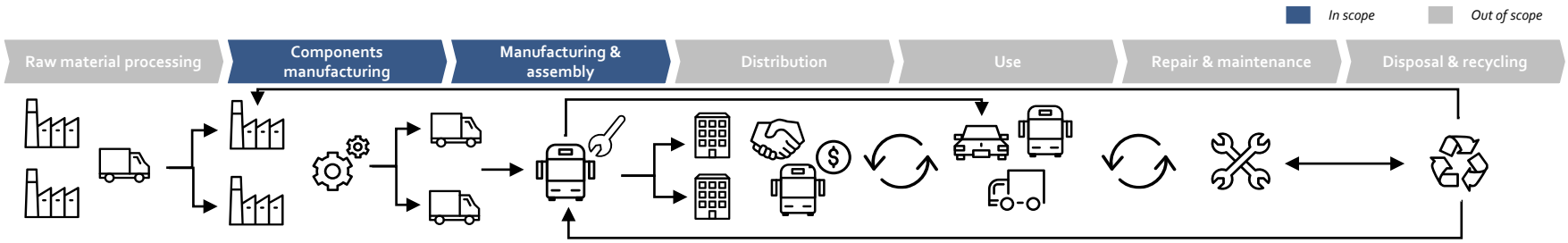
SF6 is a commonly used gas by many manufacturers of medium- and high-voltage switchgear, and although it is not poisonous, it has high global warming potential. Schneider Electric has established systems were 99% of SF6 can be recycled, recovered and reused. In addition, they can recover 97% or more of the other material in a switch gear. The equipment owner pays Schneider Electric for these recycling services.

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



	Raw material processing	Components manufacturing	Manufacturing & assembly	Distribution	Use	Repair & maintenance	Disposal & recycling
EXAMPLE ACTORS	SSAB, Hydro, outokumpu, PLASTIX	Nokian Renkaat, Raufoss Couplings, Fenno, veoneer, Ekeri	Volvo, Scania, valmet automotive	Volvo, Scania, VEHO, Bilia	DHL, DB Schenker, DSV, Nobina	Werksta, Bilskadecenter, Bilxtra, Assistor	Helik Teigen AS, Stena Recycling, Suomen Autokierrätys
KEY PRODUCTS AND SERVICES	Produces raw materials including • Steel • Aluminium • Rubber • Plastic • Glass • Fabrics	Manufactures main parts and equipment of vehicles, including • Bodies, trailers, semi-trailers • Parts, accessories and electronics (incl. engines, brakes, seats, windows, sensors, cameras, 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 the circular economy initiatives pursued by some Nordic companies in the industry

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

Inefficiency	Description of current state
UNSUSTAINABLE MATERIALS	Most input materials are recyclable (e.g. metals), however design of products is not optimized for continuous regeneration (materials are mixed together in components), which increases the use of virgin materials. The main inefficiency in terms of unsustainable materials are unsustainable sources of energy, even though the electrification of vehicles are increasing. The use of sustainable energy sources also requires significant investment in the infrastructure.
UNDERUTILISED CAPACITIES	Typically, private vehicles are left unused for long periods of time and their full capacity is not used, creating significant unnecessary costs. For rail and buses, availability and reliability are key metrics and capacity utilization is a key strategic priority for the companies. The demand forecast that creates the transport schedules can be improved by e.g. using predictive technologies, however there are natural times where there will be lower utilization (e.g. during night).
PREMATURE PRODUCT LIVES	Most vehicles and vehicle components are durable and have long lifecycles. Still, private vehicle maintenance mainly happens according to schedule, not according to need, wasting some lifecycle effects. In the public transport industry, there is a high focus on expanding the lifecycle of assets. However, maintenance schedules and plans are set up with a high degree of safety measures and rigid maintenance intervals, which can contribute to wasting some lifecycle effects as well.
WASTED END-OF-LIFE VALUE	Most manufacturing waste and the majority of end-of life products are recycled by the customer. The use of e.g. metals in the products make this attractive also from a customer perspective. However, increased complexity e.g. due to rise of customization, use of glue in fixation, advanced electronics and product documentation regulations makes recycling, repair and recovery of vehicles and trains increasingly challenging. Dedicated product take-back schemes from the manufacturer are rare.
UNEXPLOITED CUSTOMER ENGAGEMENTS	After sales and add-on sales opportunities from the manufacturers are relatively well exploited, compared to other manufacturing sub-sectors. Suppliers are actively engaging with their customers on e.g. the maintenance operations.

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

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

Reform use of resources

CIRCULAR INPUTS

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

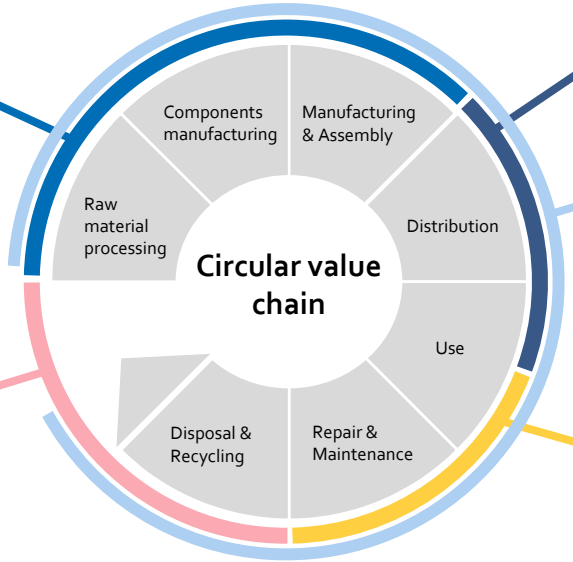
Circular supplies – Use recyclable materials in production, e.g. renewable and bio-based materials, chemicals & energy to increase recovery rates

Recover value in waste

RESOURCE RECOVERY

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 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. 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 USE 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

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

Business model	*Sub-model*
Circular Inputs	Build to last
	Circular supplies
Sharing Platform	Share
Product as a Service	Product as a service
	Performance as a service
Product Use Extension	Repair & Maintain
	Upgrade
	Resell
	Remanufacture
Resource Recovery	Recycle/upcycle
	Return

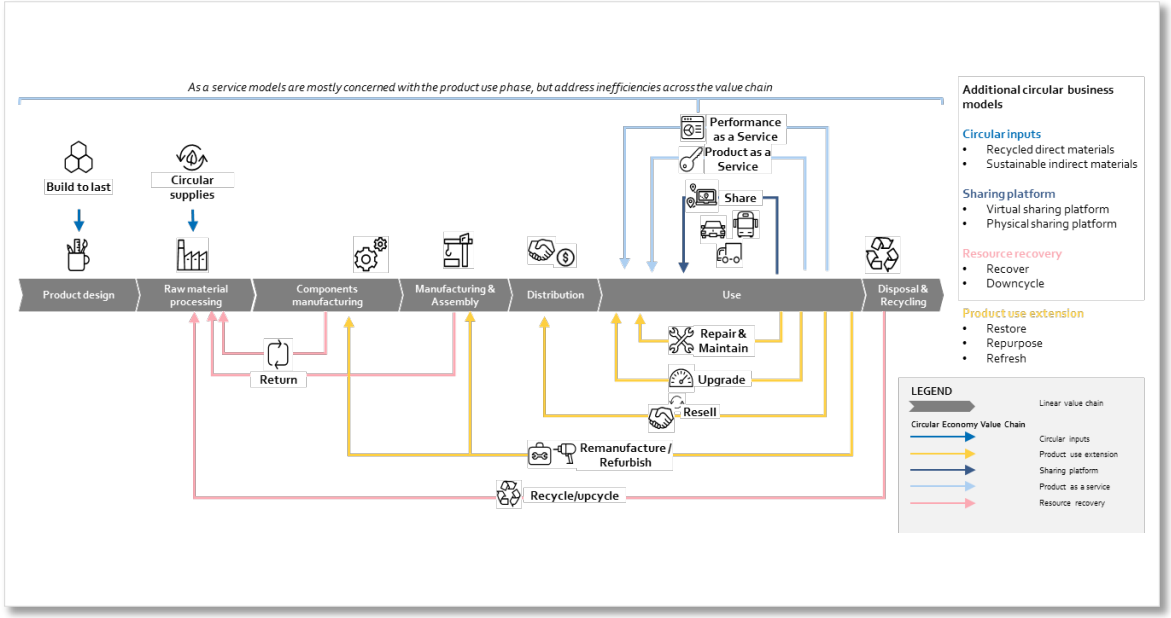


Figure: Circular business sub-models in the linear value chain

Source: Accenture, Appendix 2 for more details

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

Business model	*Sub-model*
Circular Inputs	Build to last
	Circular supplies
Sharing Platform	Share
Product as a Service	Product as a service
	Performance as a service
Product Use Extension	Repair & Maintain
	Upgrade
	Resell
	Remanufacture
Resource Recovery	Recycle/upcycle
	Return

Examples

Around one third of materials in a new Volvo truck come from recycled materials, and up to 90% of the truck can be recycled at the end of its life, thanks to labelling components for easy identification and dismantling.

Modularity and standardization in engine design have been key principles at AGCO Power for decades.

Common platforms thinking, with similar basic designs and shared parts, reduce waste in production and make the after sales operations more efficient.

Source: Company websites

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

Business model	*Sub-model*
Circular Inputs	Build to last
	Circular supplies
Sharing Platform	**Share**
Product as a Service	Product as a service
	Performance as a service
Product Use Extension	Repair & Maintain
	Upgrade
	Resell
	Remanufacture
Resource Recovery	Recycle/upcycle
	Return

Examples

TNX offers an innovative freight matching platform which matches cargo to vehicles, and optimises road transport by consolidating or bundling offers and generating dynamic and intelligent routes.

Thanks to the service, utilisation of trucks can be increased and empty running reduced.

UBER FREIGHT

Uber Freight is an on-demand freight service for trucking carriers which connects truck drivers with cargo that needs to be hauled long distances.

The goal of the service is to reduce the hassles of trucking, including e.g. downtime and deadhead miles.

Source: Company websites

The product as a service models strengthen customer relationships through shared risk and frequent interaction

Business model	*Sub-model*
Circular Inputs	Build to last
	Circular supplies
Sharing Platform	Share
Product as a Service	Product as a service
	Performance as a service
Product Use Extension	Repair & Maintain
	Upgrade
	Resell
	Remanufacture
Resource Recovery	Recycle/upcycle
	Return

Examples

MICHELIN

Tire as a Service leasing programme allows Michelin customers to lease tires against a pay-per-mile fee.

The service allows Michelin to establish the necessary control to re-introduce tires returned at the end of the leasing period, while reducing the risk associated with replacement for customers.

The company also offers sensor based-data analytics for predictive maintenance and fuel optimization.

MAN

MAN offers trucks-as-a-service on a pay-per-use basis.

MAN owns the truck and uses telematics and digital connectivity to manage the risk and maintenance of the truck while the fleet operator is responsible for the fuel and driver costs.

VOLVO

Volvo Service Agreements guarantee the best possible uptime for buses and trucks against a monthly fee.

For example, the Volvo Gold Contract includes 100% uptime promise, remote diagnostics and preventive maintenance, and covers all repairs.

Source: Company websites

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

Business model	*Sub-model*	*Examples*
Circular Inputs	Build to last	
	Circular supplies	
Sharing Platform	Share	
Product as a Service	Product as a service	
	Performance as a service	
Product Use Extension	Repair & Maintain	
	Upgrade	
	Resell	
	Remanufacture	
Resource Recovery	Recycle/upcycle	
	Return	

ALSTOM

HealthHub is a condition-based predictive maintenance tool that monitors the health of trains, train infrastructure and signaling systems.

The tool uses advanced data analytics to extend and maintain the useful life of trains.

RENAULT

Renault reuses parts coming from its end-of-life vehicles, sales network, plants or suppliers, and sells these second-hand parts (body, lights, shield, etc.) through affordable repair offers.

RENAULT

Renault reconditions or remanufactures used parts, which are collected in the sales network, sorted and refurbished.

The process involves complete dismantling, cleaning, sorting, refurbishment and replacement of faulty or worn parts, reassembly and inspection.

SCANIA

Scania Service Exchange takes used and worn components (e.g. engines, gearboxes and clutch parts), strips them down completely and remanufactures them.

Components are remanufactured to the original Scania specifications and then tested exactly as brand new parts, and finally resold at a lower price.

Source: Company websites

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

Business model	*Sub-model*	*Examples*
Circular Inputs	Build to last	
	Circular supplies	
Sharing Platform	Share	
Product as a Service	Product as a service	
	Performance as a service	
Product Use Extension	Repair & Maintain	
	Upgrade	
	Resell	
	Remanufacture	
Resource Recovery	Recycle/upcycle	
	Return	

Nokian Renkaat

Scrap tyres, or tyres that do not meet quality standards, are taken to recycling directly from production.

79% of production waste is recycled, 11% recovered as energy, and 8% reused.

Discarded tyres serve various reuse and recycling applications, they can e.g. be utilised as material or for energy production.

Ford

Ford performs closed-loop recycling, with auto parts materials recycled back to the same use.

For example, the company recycles 5 million pounds of aluminium scrap a week, which is enough to build 37,000 new F-series truck bodies.

Ford also upcycles some materials, such as milk bottles to be used as automotive components and industrial fabrics to be used in seats.

GM

GM recycles 84% of its worldwide manufacturing waste and has 111 landfill-free facilities.

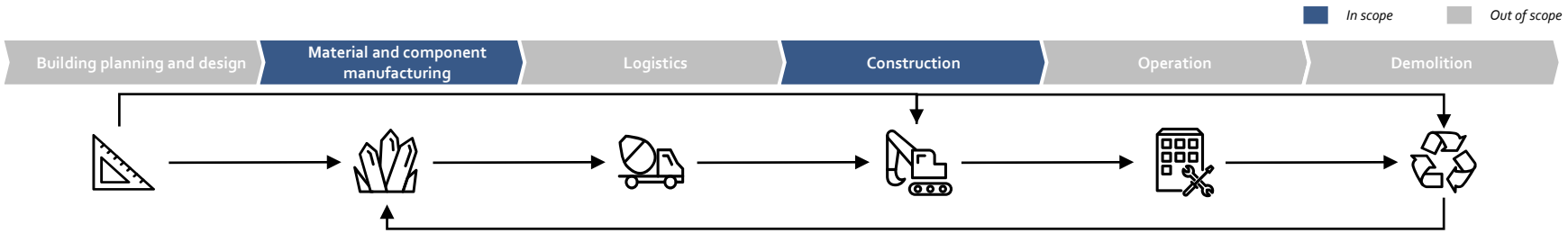
By-product recycling and reuse generates approximately $1bn in annual revenue for the company.

Source: Company websites

Construction

Current state analysis and circular opportunities

The construction value chain is fragmented with numerous suppliers who have various circular maturity levels



	Building planning and design	Material and component manufacturing	Logistics	Construction	Operation	Demolition
EXAMPLE ACTORS	SWECO, ppm, COWI	SAINT-GOBAIN, Wienerberger, Caverion, KONE	bring, postnord, DB SCHENKER	NCC, SKANSKA, VEIDEKKE	COOR, Toma FACILITY MANAGEMENT	Remeo, SORTERA Group, NG Norsk Gjenvinning
KEY PRODUCTS AND SERVICES	Provides planning and design for the components, systems and ultimately the complete building, including material choices.	Produces materials, such as gypsum boards, cement or steel, and partly/fully assembled components such as ventilation systems, elevators or floor panels.	Transports material and components from the production site to the construction site and transports packaging and surplus material away from the construction site.	Constructs the complete building on the site, including cutting and assembling of individual components.	Operates the building to accommodate the requirements of the tenants, such as energy management and required maintenance, upgrades and refurbishment.	Demolition of the building and separation of components and material if possible. The material is either recycled or sent to landfill.
EXAMPLE CE INITIATIVES*	Build to last - buildings are planned to be energy efficient at the operation phase and use of material banks to track material information throughout the lifecycle	Circular supplies - the end materials are made of recyclable materials and materials that are durable	• *N/A*	Build to last - use of pre-fabricated and modular components which minimizes waste generation at the site	• Product and performance as a service - selling lightning as a service instead of a product • Circular supplies - smart energy management	• Recycle/upcycle and return - recycle construction waste • Sharing platform - re-selling of surplus material or waste material

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

Inefficiencies occur in all parts of the construction value chain

Inefficiency	Description of current state
UNSUSTAINABLE MATERIALS	Virgin materials are normally used rather than secondary materials or materials with recycled content. This is because recycled materials have the same quality requirements as virgin products and since virgin material is so cheap, recycled material is not able to compete on the price. The construction sector is a large generator of waste, waste from the construction sector accounts for 30-40% of the total waste generated in the Nordics.[1]
UNDERUTILISED CAPACITIES	During the construction process, equipment and logistics assets present areas with underutilized capacities. Equipment used in construction process are typically idle for long time periods. Due to a fragmented supplier market and use of multiple suppliers in the construction process it is challenging to optimize logistics to and from the construction site causing large inefficiencies in transportation. Buildings are often underutilized during the lifetime as both buildings and leases offer limited flexibility.
PREMATURE PRODUCT LIVES	Typically, buildings are built for a specific purpose and as user needs changes it is difficult to repurpose the buildings, causing buildings to be decommissioned prematurely. Since the cost of building and the cost of operating and maintaining buildings are often not born by the same actors, buildings are built with poor material and design choices. As a result of this, buildings are taken down prematurely and potential lifecycles are wasted.
WASTED END-OF-LIFE VALUE	Complexity in construction and lack of information about how the built asset is assembled make recycling and recovery of materials challenging because components can not be disassembled, and materials can not be separated from each other. Buildings are built for a long lifetime and take back-schemes from manufacturers of components at end of life are very rare.
UNEXPLOITED CUSTOMER ENGAGEMENTS	There is often a lack of communication between building owners and entrepreneurs resulting in limited discussions on finding optimal, sustainable solutions and on options for product use extension and repurposing of buildings.

1 https://norden.diva-portal.org/smash/get/diva2:1188884/FULLTEXT01.pdf

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

Therefore, construction companies should explore the five circular business models

Reform use of resources

CIRCULAR INPUTS

Build to last – Design components and buildings that are durable, easy to repair and can accommodate the needs of different tenant groups (e.g. modular)

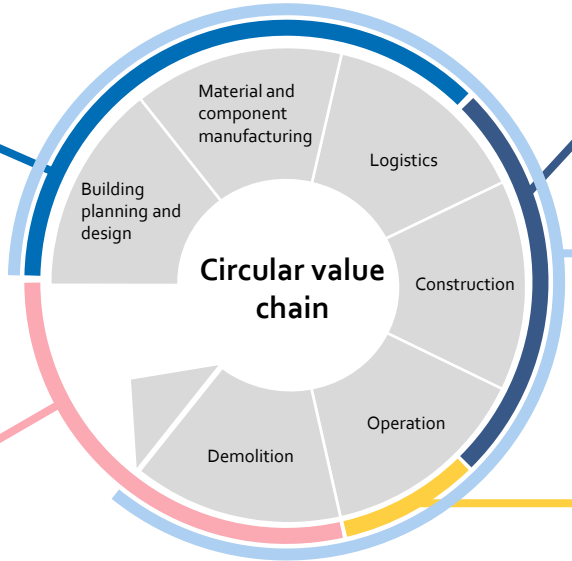
Circular supplies – Use recyclable materials in production, e.g. renewable and bio-based materials, chemicals & energy to increase recovery rates

Recover value in waste

RESOURCE RECOVERY

Recycle/upcycle – Collect and recover materials of end-of-life buildings and reuse them

Return – Return wasted parts and materials from the building site to the source



Optimise capacity use

SHARING PLATFORM

Share – Develop solutions that enable increased capacity use of the buildings

Offer outcome-oriented solutions

PRODUCT AS A SERVICE

Product as a service – Offer customers to use the components against a subscription fee or use-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

Extend lifecycles

PRODUCT USE EXTENSION

Repair & maintain – Deliver repair and maintenance services to extend the life of existing buildings in the market

Upgrade – Improve building performance by upgrading existing components or material with newer ones

Resell – Resell components or material 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 components or material, and remarket them with lower price

Source: Accenture, Appendix 2 for more details

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

Business model	*Sub-model*
Circular Inputs	Build to last
	Circular supplies
Sharing Platform	Share
Product as a Service	Product as a service
	Performance as a service
Product Use Extension	Repair & Maintain
	Upgrade
	Resell
	Remanufacture
Resource Recovery	Recycle/upcycle
	Return

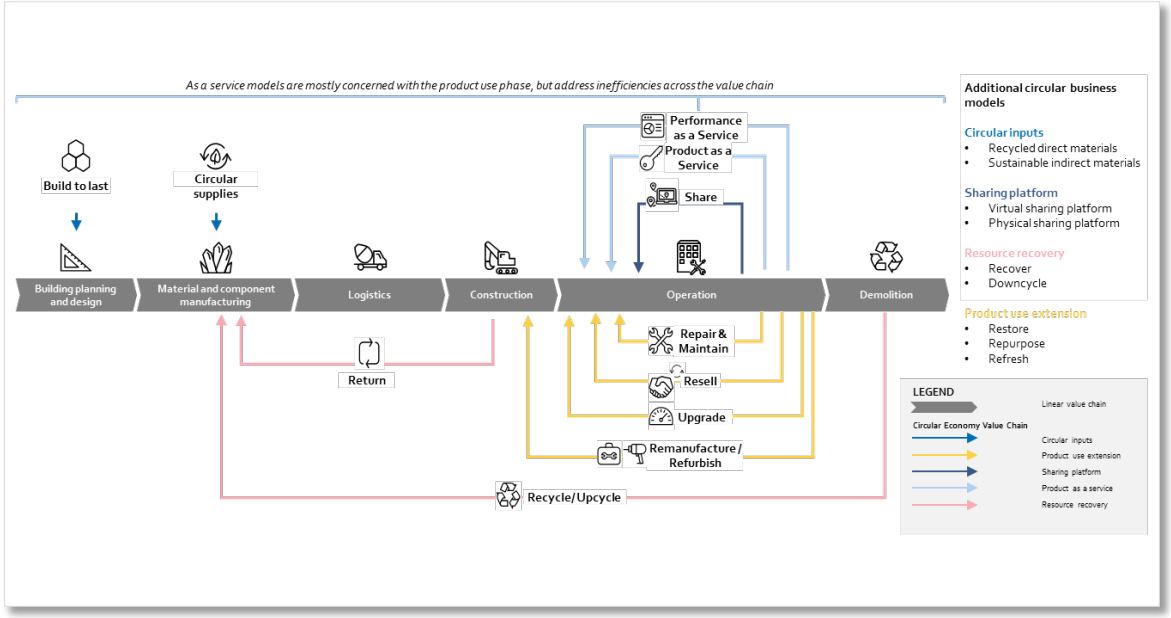


Figure: Circular business sub-models in the linear value chain

Source: Accenture, Appendix 2 for more details

Modular design principles and documenting and tracking materials facilitate recovery of materials at end of life

Business model	*Sub-model*	*Examples*
Circular Inputs	Build to last	Moelven has designed Modus system walls, where the components are designed to be able to be taken apart and reassembled in a new design. When business needs change, the design of the room can be changed without having to add new materials as the walls can be moved and reused.
	Circular supplies	
Sharing Platform	Share	
Product as a Service	Product as a service	The Madaster platform creates transparency in the built environment through allowing product and material data to be stored, enriched, shared and managed throughout the building lifecycle. The material passport gives insight into materials, components and products used to create a building, and into their quantities.
	Performance as a service	
Product Use Extension	Repair & Maintain	SpaceIQ uses sensor data in its comprehensive workplace platform to allow customers to optimize the use of office space. The platform combines all relevant data sources such as employee information, floor charts, facility services etc.
	Upgrade	
	Resell	
	Remanufacture	
Resource Recovery	Recycle/upcycle	
	Return	

Source: Company websites

Sharing platforms are relevant in the construction phase and building use phase, where they enable resource and capacity optimisation

Examples

netlet

Netlet collects surplus material from construction sites and sell it discounted through their platform and in stores. In that way Netlet works as an enabler for construction companies, contributing to reducing waste from the construction industry.

PLASTCOM

The plastic resale platform is a marketplace specially developed for the plastic industry, allowing companies to sell and buy slow-moving stock, virgin leftovers, production waste etc.

airbnb

Airbnb is an online marketplace that connects people who want to rent out their homes with people who are looking for accommodation.

Source: Company websites

The product as a service models contributes to sharing of risk between building owners and users and minimizing the total lifecycle cost

Business model	*Sub-model*
Circular Inputs	Build to last
	Circular supplies
Sharing Platform	Share
Product as a Service	Product as a service
	Performance as a service
Product Use Extension	Repair & Maintain
	Upgrade
	Resell
	Remanufacture
Resource Recovery	Recycle/upcycle
	Return

Examples

PHILIPS

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.

wework

WeWork provides flexible shared workspaces allowing companies to lease office space "by the seat", with all of the IT and communications included. The solution enables companies to grow and shrink office footprints according to their needs

TEMPORARY SPACE NORDICS

Temporary Space rents building modules to schools, offices, kindergardens and to other purposes. The modules allows the customers to increase their capacity when needed, without spending resources on expanding their premises permanently. When additional capacity is no longer needed, Temporary Space recovers the modules and rents them out to other customers.

Source: Company websites

Various services can significantly prolong the lifecycle of a building, such as refurbishment of old buildings

Business model	*Sub-model*
Circular Inputs	Build to last
	Circular supplies
Sharing Platform	Share
Product as a Service	Product as a service
	Performance as a service
Product Use Extension	Repair & Maintain
	Upgrade
	Resell
	Remanufacture
Resource Recovery	Recycle/upcycle
	Return

Examples

NCC

An increasingly important market for NCC is refurbishment of residential buildings and offices from the 1960s and 70s. One example is the Portland Towers in the Port of Copenhagen, which has been transformed from cement silos to modern offices. During the refurbishment project, a total of seven floors were added to the outside of the silos.

VEIDEKKE

Veidekke is currently renovating the existing building stock of a nursing home in Norway. In this project, Veidekke will make changes to the floorplan and install new surfaces, new technical systems and additional rooms. The roofs, ceilings and facades will also be renovated, including installing additional insulation. Solar panels will also be installed on the roof to further reduce the energy needs of the building.

FRAM EIENDOM

Fram Eiendom is a real estate development company which specializes in acquisition and development of high quality properties. In spring 2020, they completed the Valkyrien project in Oslo, which refurbished six individual properties and connected them together to establish a joint department store and apartment complex. The work included complete alterations to the floor plans, new surfaces, new facades etc., while still retaining the old material and components where possible.

Source: Company websites

Construction waste is a large challenge for the industry, but there are several ongoing initiatives

Business model	*Sub-model*
Circular Inputs	Build to last
	Circular supplies
Sharing Platform	Share
Product as a Service	Product as a service
	Performance as a service
Product Use Extension	Repair & Maintain
	Upgrade
	Resell
	Remanufacture
Resource Recovery	Recycle/upcycle
	Return

Examples

Gamle Mursten upcycles old bricks for new buildings. Thanks to a patented cleaning technology, called the REBRICK process, the company ensures that building waste can be recycled. Old bricks are cleaned, sorted manually and stacked by robots and sold for new building and renovation projects where clients want to minimize the impact of unnecessary CO_2 emissions on the environment.

AF Gruppen has developed new technology to harvest, clean and recycle contaminated construction materials, extracting 80% of the mass as reusable materials and 20% as contaminated mass for further treatment.

The real estate developer JM is working together with the recycler Norsk Gjenvinning to recycle construction waste from JM's construction sites in Norway. Currently, they are recycling 68% of all construction waste, which makes them a leading company in the construction industry. One example is the waste from wood, which is sorted at the construction site, processed by Norsk Gjenvinning and finally used in furniture production in Sweden.

Source: Company websites

Key contacts

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

Marthe Haugland
Senior Innovation Advisor
+47 971 35 126
m.haugland@nordicinnovation.org

Nordic Innovation

Jyri Arponen
Senior Lead, Business Development
+358 40 766 2906
jyri.arponen@sitra.fi

SITRA

Anna Belvén Töndevold
Nordic Sustainability Strategy Lead
+46 730 51 32 96
anna.b.tondevold@accenture.com

accenture

Appendix 1

Current state analysis and circular opportunities

INTRODUCTION

Circular maturity survey

Purpose	The Circular maturity survey was conducted to understand the starting point of Nordic manufacturing SMEs in adopting the 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, 28 Nordic manufacturing SMEs replied to the survey. The responses were collected in workshops and through an online survey in September – October 2020. Detailed results of the survey are presented in the following pages.

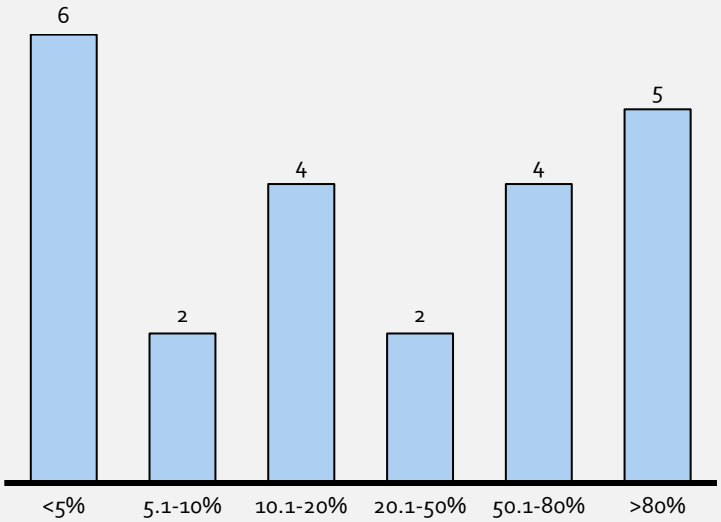
RESULTS – CIRCULAR MATURITY SURVEY

Inefficiency assessment (1/5)

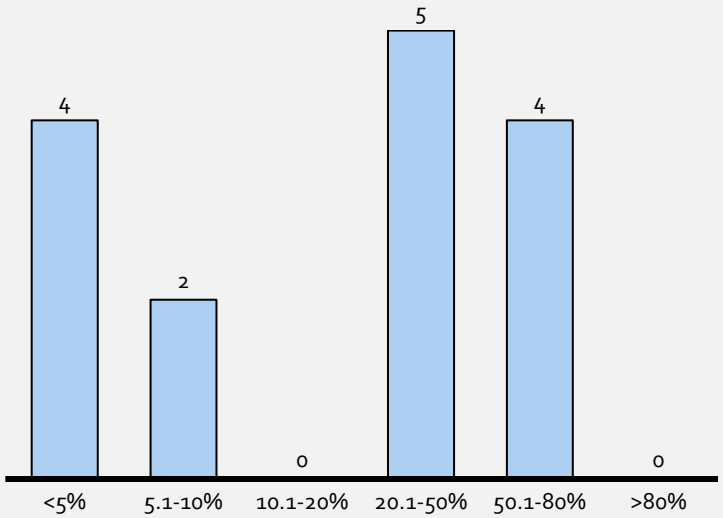
1) Unsustainable materials

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 spent on circular material such as renewable, recycled or reused materials?



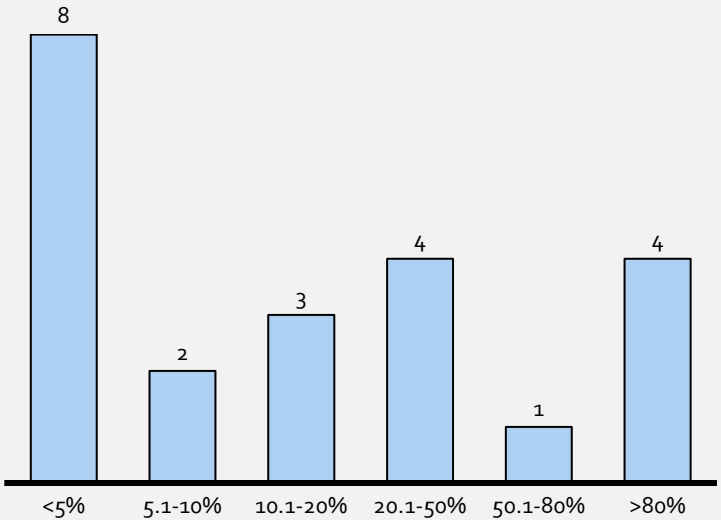
RESULTS – CIRCULAR MATURITY SURVEY

Inefficiency assessment (2/5)

2) Underutilised capacity

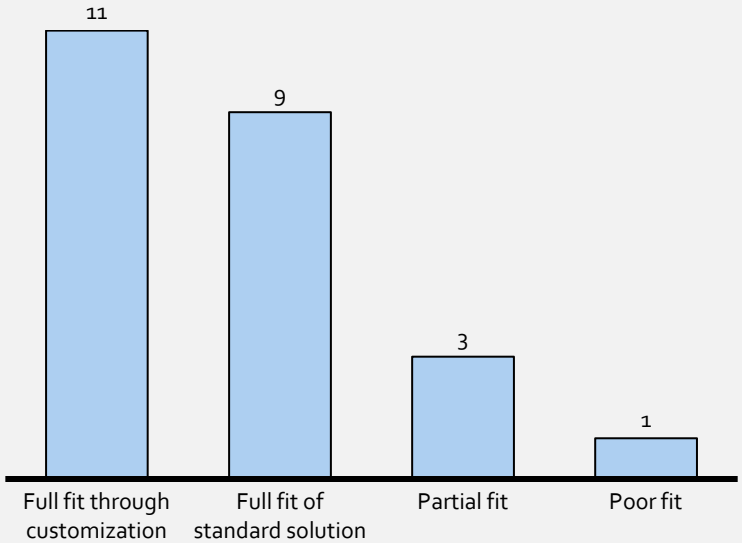
Underutilised or unused products and assets (e.g. products are not operating full hours or full functionality is not used)

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?



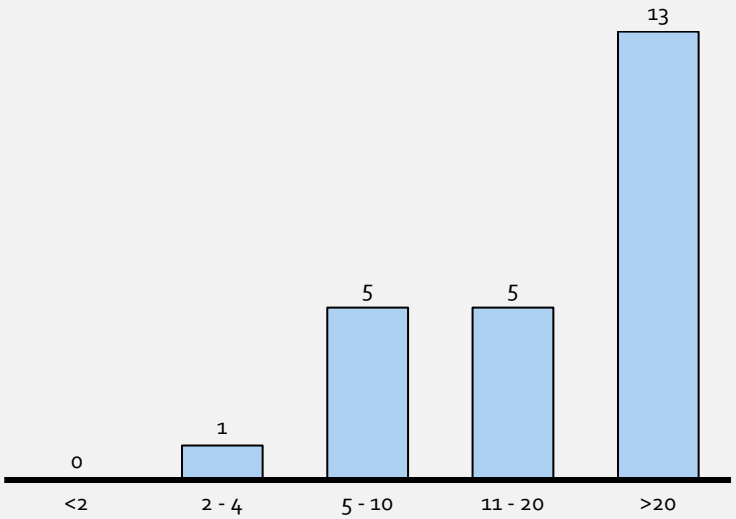
RESULTS – CIRCULAR MATURITY SURVEY

Inefficiency assessment (3/5)

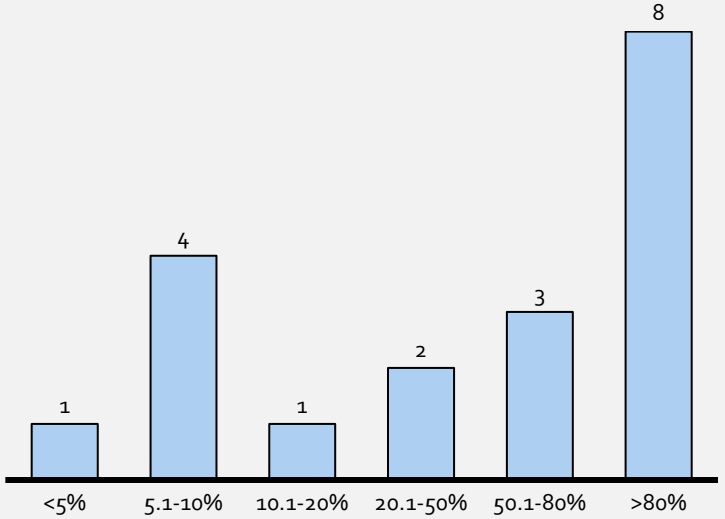
3) Premature product lives

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



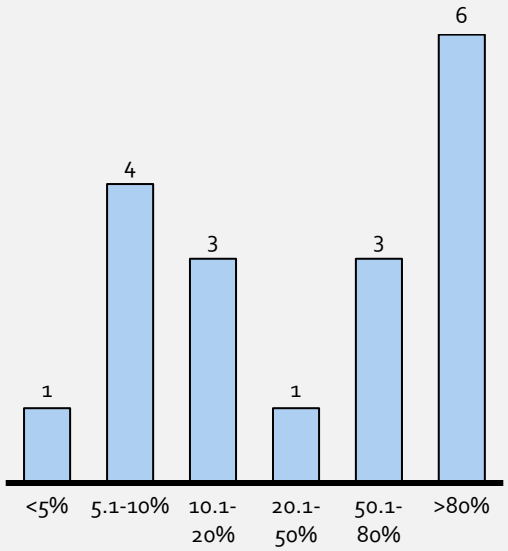
RESULTS – CIRCULAR MATURITY SURVEY

Inefficiency assessment (4/5)

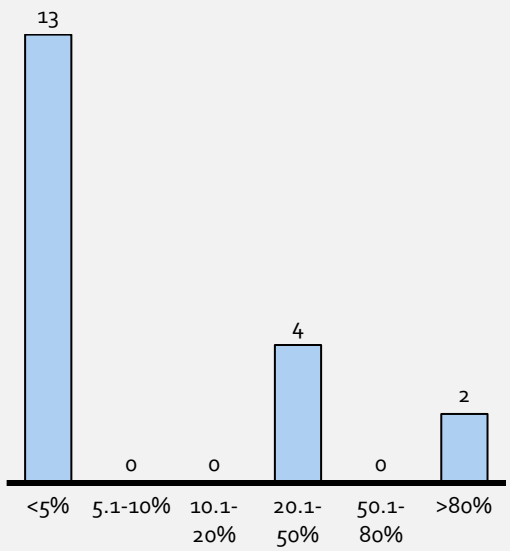
4) Wasted end-of-life value

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

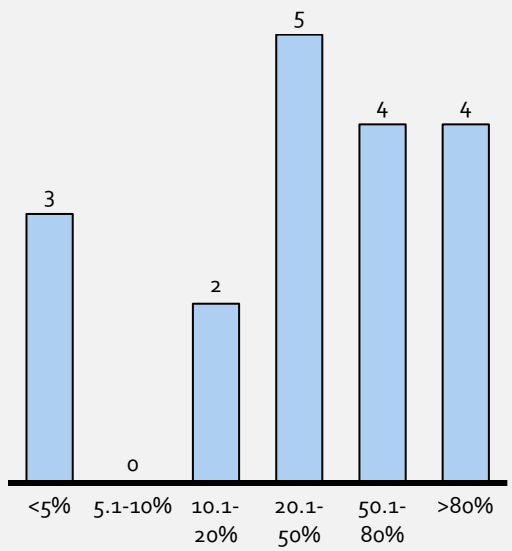
Waste in production: % of waste from production that is recycled (based on weight)



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



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



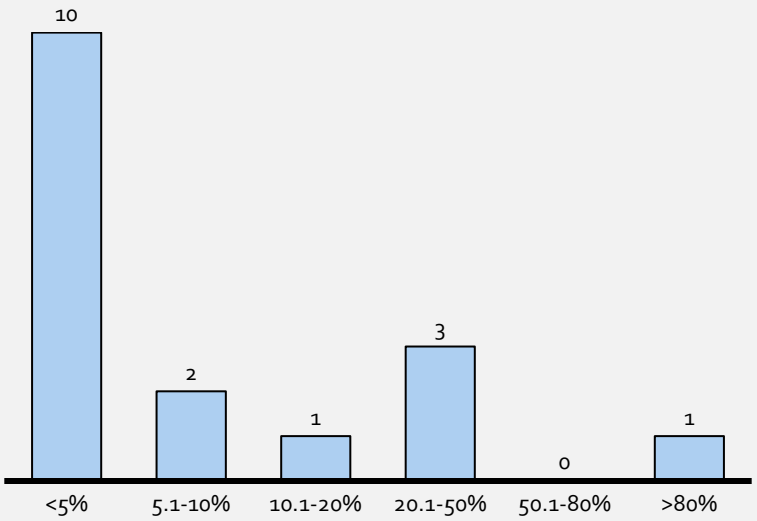
RESULTS – CIRCULAR MATURITY SURVEY

Inefficiency assessment (5/5)

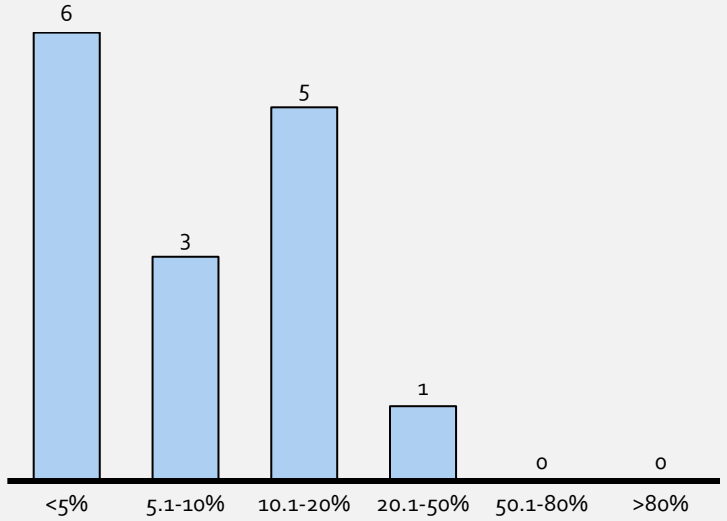
5) Unexploited customer engagements

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

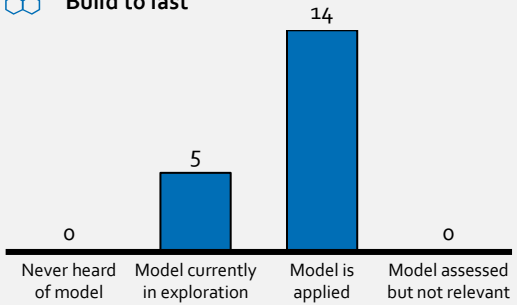


RESULTS – CIRCULAR MATURITY SURVEY

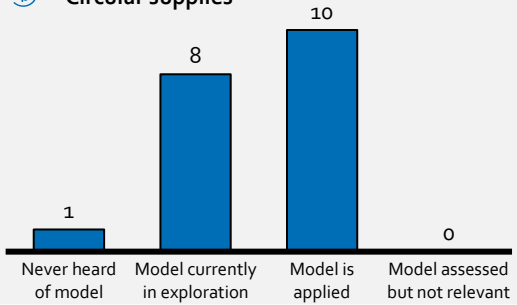
Business model adoption (1/2)

CIRCULAR INPUTS

Build to last

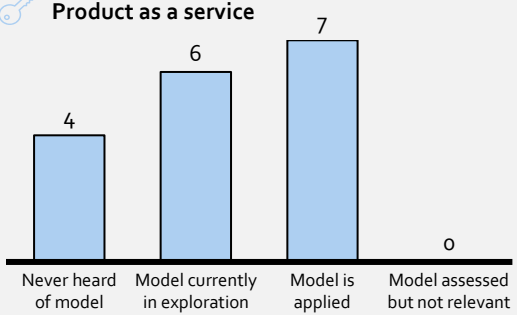


Circular supplies

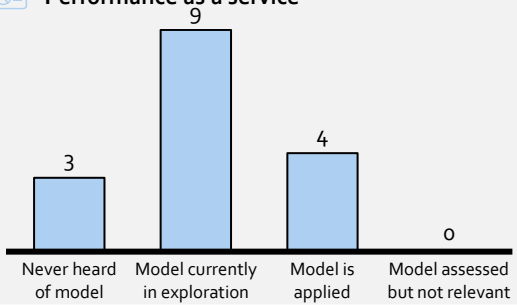


PRODUCT AS A SERVICE

Product as a service

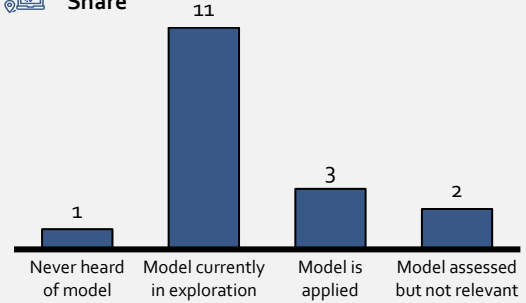


Performance as a service



SHARING PLATFORMS

Share

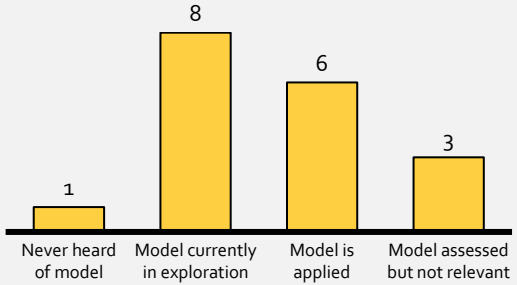


RESULTS – CIRCULAR MATURITY SURVEY

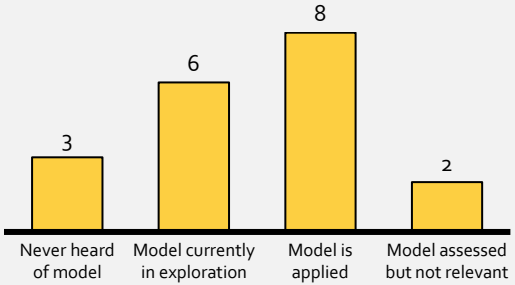
Business model adoption (2/2)

PRODUCT USE EXTENSION

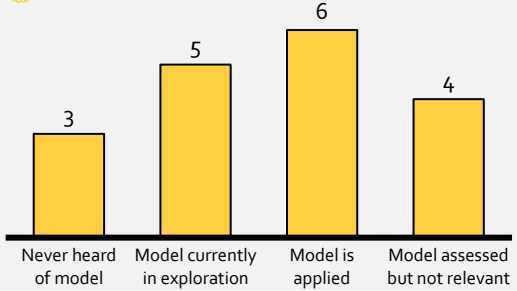
Repair & maintain



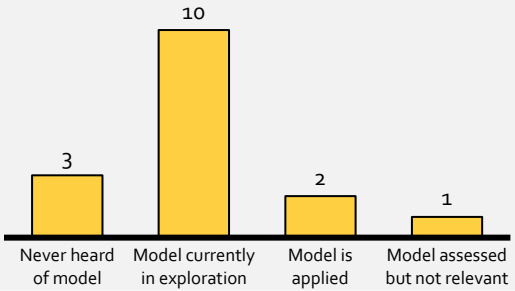
Upgrade



Resell

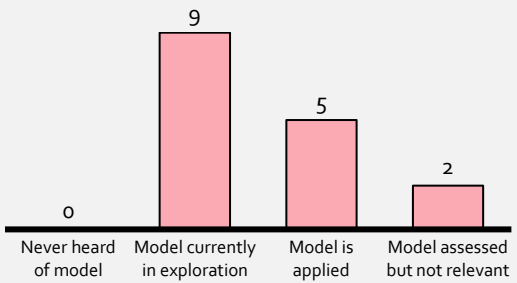


Remanufacture

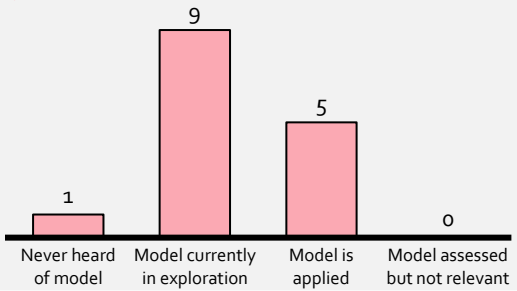


RESOURCE RECOVERY

Recycle / upcycle



Return

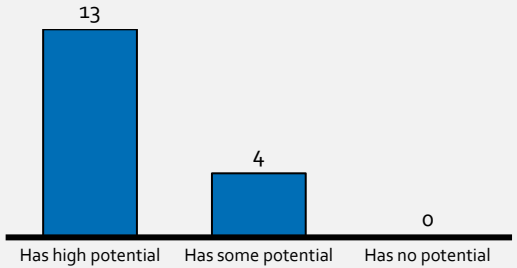


RESULTS – CIRCULAR MATURITY SURVEY

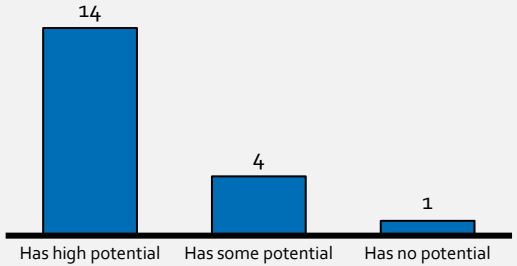
Business model potential (1/2)

CIRCULAR INPUTS

Build to last

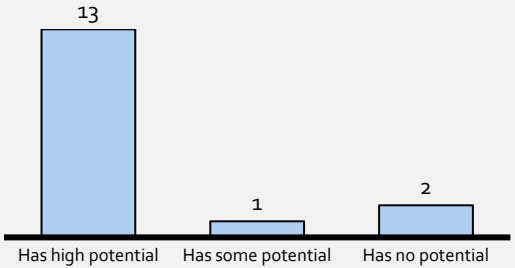


Circular supplies

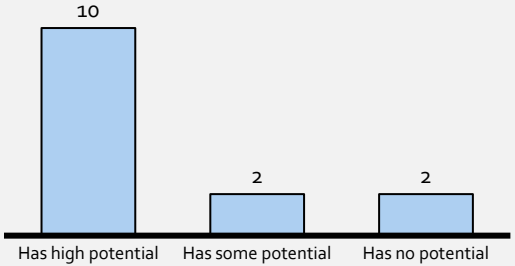


PRODUCT AS A SERVICE

Product as a Service

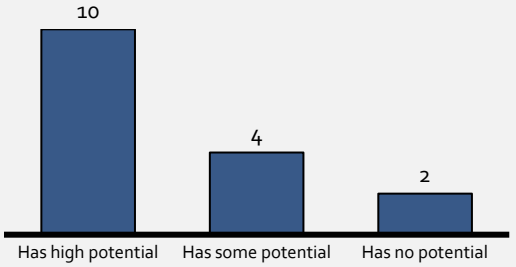


Performance as a service



SHARING PLATFORMS

Share

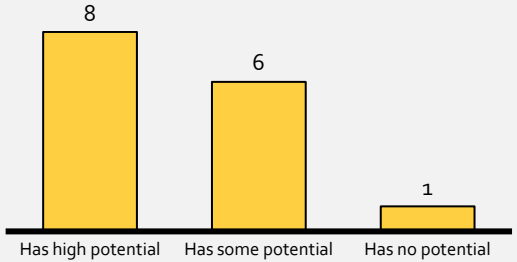


RESULTS – CIRCULAR MATURITY SURVEY

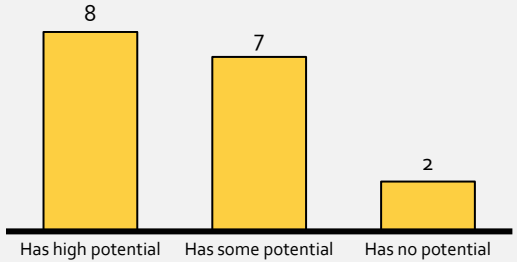
Business model potential (2/2)

PRODUCT USE EXTENSION

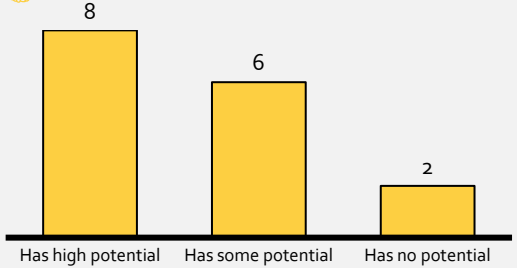
Repair & maintain



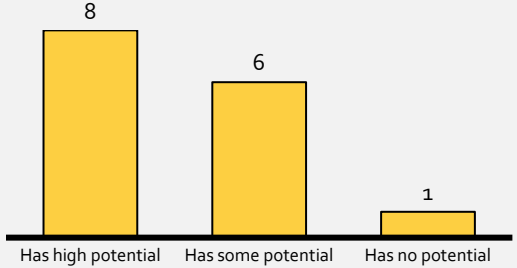
Upgrade



Resell

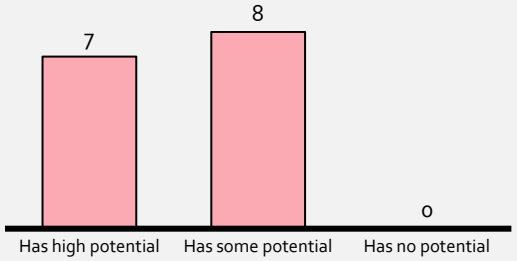


Remanufacture

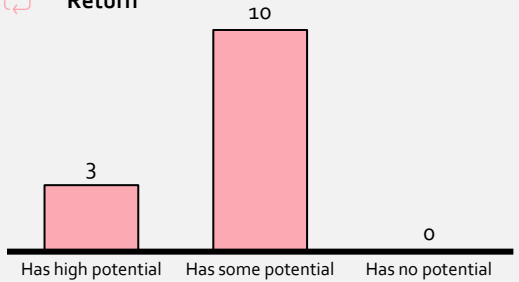


RESOURCE RECOVERY

Recycle / upcycle



Return



Appendix 2

Additional details on sources

ADDITIONAL DETAILS ON SOURCES

Content	Playbook pages	Source
5 Circular business models	13, 37, 42, 145, 155, 165, 175	• Accenture – Lacy, P. & Rutqvist, J. (2015). *Waste to Wealth: The Circular Economy Advantage*. 1st ed. English: Palgrave Macmillan. • Accenture – Lacy, P., Long, J. & Spindler, W. (2020). *The Circular Economy Handbook: Realizing the Circular Advantage*. 1st ed. English: Palgrave Macmillian.
3 drivers for Circular Economy	10, 22	• Accenture presentation, Circular Materials Conference (2018) • Adapted from Accenture – Lacy, P., Long, J. & Spindler, W. (2020). *The Circular Economy Handbook: Realizing the Circular Advantage*. 1st ed. English: Palgrave Macmillian.
4 types of inefficiencies in the linear value chain	11, 20	• Accenture – Lacy, P. & Rutqvist, J. (2015). *Waste to Wealth: The Circular Economy Advantage*. 1st ed. English: Palgrave Macmillan • Accenture presentation, Circular Materials Conference (2018) • Accenture – 3D Printing vs 3D-TV: https://www.accenture.com/no-en/insight-3d-printing-vs-3d-tv
Development of resource demand	24	• Accenture – Lacy, P. & Rutqvist, J. (2015). *Waste to Wealth: The Circular Economy Advantage*. 1st ed. English: Palgrave Macmillan
Circular technology development	16, 25, 92	• 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)
Circular technology descriptions	93 - 101	• Adapted from Accenture – Lacy, P., Long, J. & Spindler, W. (2020). *The Circular Economy Handbook: Realizing the Circular Advantage*. 1st ed. English: Palgrave Macmillian. • 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	14, 35, 38, 39, 146, 156, 166, 176	• Adapted from Accenture – Lacy, P., Long, J. & Spindler, W. (2020). *The Circular Economy Handbook: Realizing the Circular Advantage*. 1st ed. English: Palgrave Macmillian. • Accenture presentation, Circular Materials Conference (2018)
9 Circular capabilities	15, 51, 52	• Adapted from: Accenture – Lacy, P. & Rutqvist, J. (2015). *Waste to Wealth: The Circular Economy Advantage*. 1st ed. English: Palgrave Macmillan.
Industry X.0	88, 89	• 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	103	• 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	111	• 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
Sustainable value creation framework	12, 29	• Accenture – Lacy, P., Long, J. & Spindler, W. (2020). *The Circular Economy Handbook: Realizing the Circular Advantage*. 1st ed. English: Palgrave Macmillian.