

Towards sustainable manufacturing through collaborative circular economy strategies

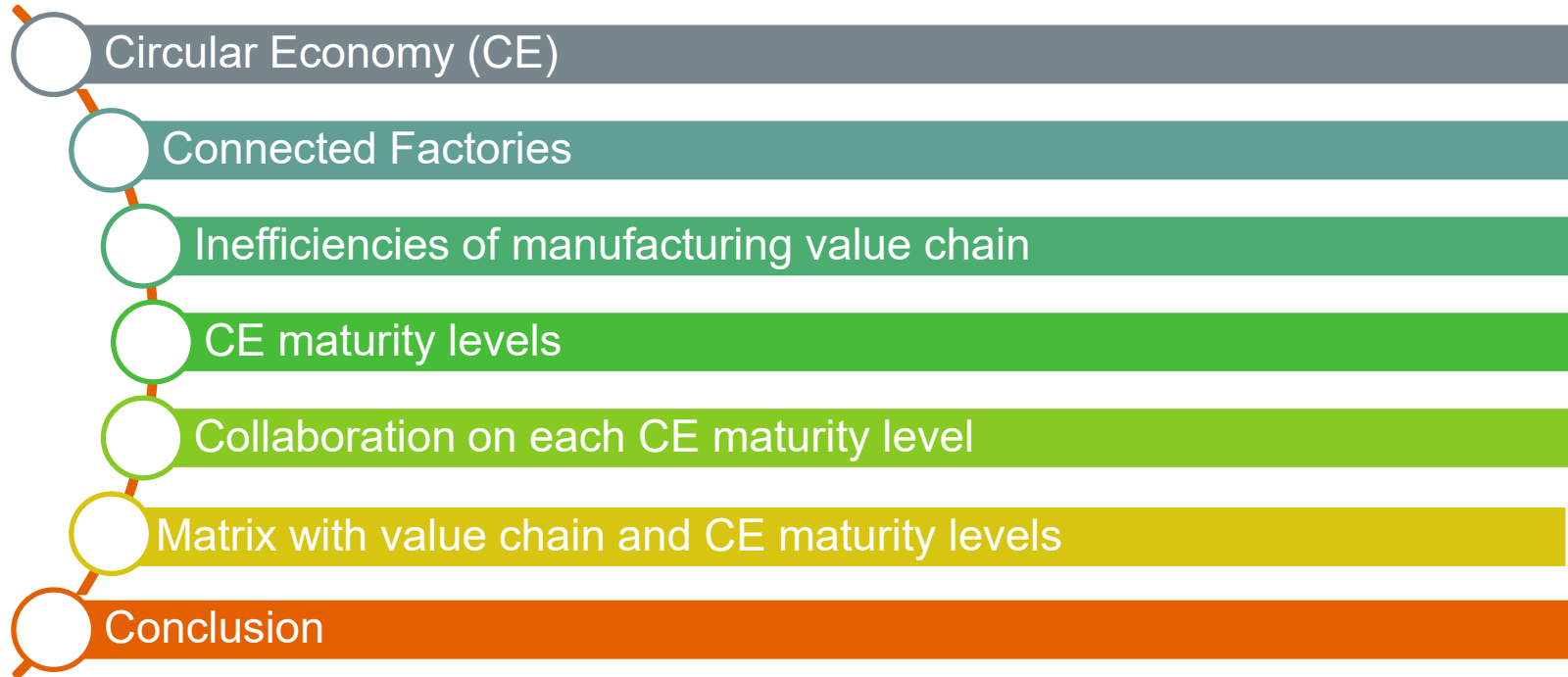
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Outline



Circular Economy (CE)

CE is an economy constructed from societal production-consumption systems that maximizes the service produced from the linear nature-society-nature material and energy throughput flow.

This is done by using cyclical materials flows, renewable energy sources and cascading type energy flows.

J. Korhonen, A. Honkasalo, and J. Seppälä, 'Circular economy: The concept and its limitations', *Ecol. Econ.*, vol. 143, pp. 37–46, Jan. 2018.

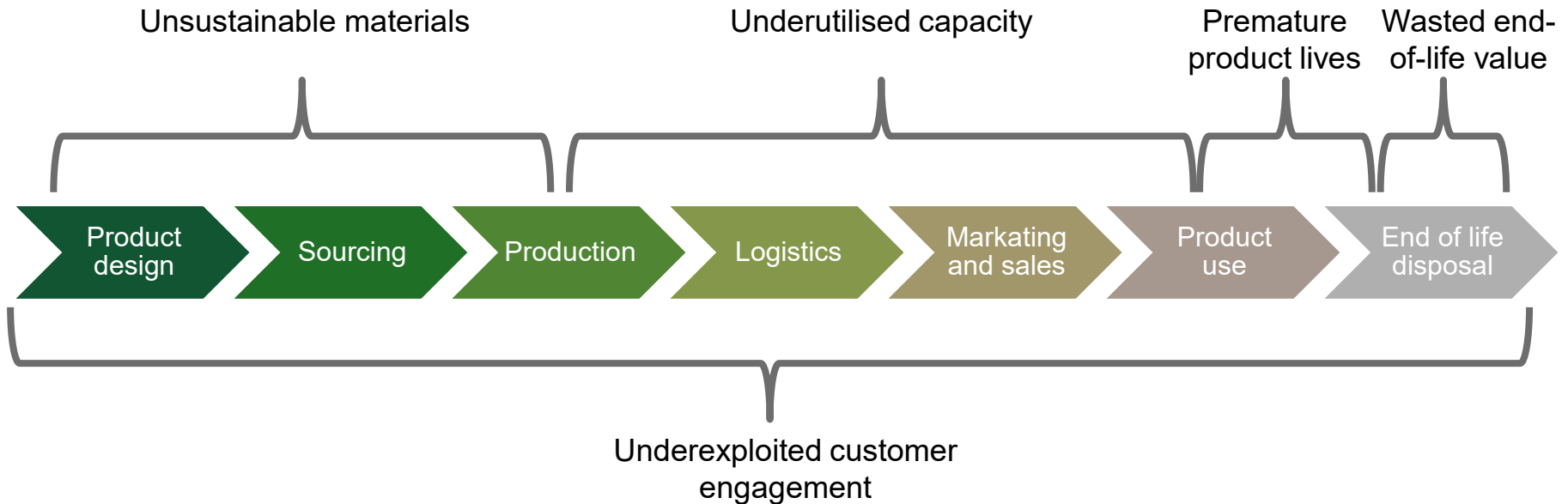
Connected Factories 2



- **Coordination and support action (CSA)** to cross-fertilise the Industrial Platform communities, allowing for easier take-up of digital technologies from research to real-world use cases, and supporting the transfer of skills and know-how
- **DT-ICT-07-2018-2019 Digital manufacturing platforms**
- 19 partners
- <https://www.effra.eu/connectedfactories>
- EFFRA = European Factories of the Future (FoF) Research Association



Inefficiencies on the manufacturing value chain



[SITRA](#) (The Finnish Innovation Fund), Technology Industries of Finland, and Accenture, *Circular Economy Business Models for the Manufacturing Industry: Circular Economy Playbook for Finnish SMEs*. <https://teknologiateollisuus.fi/fi/circular-economy-playbook>

CE maturity levels



Collaboration in the DMP* projects

Level	Instance of collaboration	Projects and solutions
Linearity	No collaboration, prevalence of make–take–dispose paradigm.	No instances among CF2 projects.
Industrial CE piloting	Collaboration and experimentation with external industrial actors, with an emphasis on production and logistics.	QU4LITY : quality pilots on the reduction of unnecessary scrap material and augmented reality (AR) demos to support the maintenance. European Factory Platform : logistics traceability via blockchain .
Systemic material management	Integrated concerns with opportunities to reuse, refurbish, recycle and remanufacture materials.	Kyklos : automatic product design for a personalised 3D-printed wheelchair with AR manuals . TRICK : tracing ‘from sheep to shop’ via blockchain . European Factory Platform : digital marketplace with automated B2B matchmaking and new market opportunities. AI.SOV: AI -based solution to forecast and optimise spare parts production .
CE thinking	Commitment to an industrial symbiosis network in which the ultimate goal is to leverage a closed-loop supply chain.	Kyklos : in addition to the web-based configuration tool (a digital twin), the IoT is embedded in the product, enabling predictive maintenance . European Factory Platform : smart waste management with connected factories, real-time data analytics and blockchain .
Full circularity	Aspirational goals reflecting a broad understanding of value flows and the co-creation of new value circles within manufacturing networks.	None to date.

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Matrix

CE maturity levels/ manufacturing value chain	Linearity	Industrial CE Piloting	Systemic Materials Management	CE Thinking	Full Circularity
Product design					
Sourcing					
Production					
Logistics					
Marketing and sales					
Product use					
End of life disposal					

Product design

Linear value chain	Linearity	Industrial CE piloting	Systemic material management	CE thinking	Full circularity
Product design	Product design does not consider durability, upgradeability, circularity or sustainability.	Company considers transition from the use of unsustainable and hazardous substances to sustainable raw materials. Company has piloted the repair or reuse of products.	Durability and upgradeability of products is promoted and applied. Personalisation of products is driven by demand and purpose.	Environmental impact assessment is a driving force of product development (eco design). Products are designed to avoid loss and premature end-of-life.	Products are fully circular by design, enhancing purpose-based durability during the life-cycle and enabling multiple reuse, repair, remanufacturing and regenerative recycling at end-of-life.

Sourcing

Linear value chain	Linearity	Industrial CE piloting	Systemic material management	CE thinking	Full circularity
Sourcing	No actions to reduce the consumption of energy and/or materials are being implemented. Materials are sourced based on performance and price.	Company seeks to minimise inputs of energy and materials. Material sourcing is being shifted from unsustainable to sustainable raw materials.	Sourcing is based on code of conduct guidelines for circularity and the sustainability of materials. The amount of waste is minimised and side streams are utilised.	Raw materials are sourced mainly from known and monitored secondary markets and through reverse logistics. Social impacts are considered in the sourcing process.	Full circularity is enabled by sustainable materials that have less environmental impact (on biodiversity, climate change, acidification, etc.) than traditional counterparts.

Production

Linear value chain	Linearity	Industrial CE piloting	Systemic material management	CE thinking	Full circularity
Production	Operations of the company meet environmental regulations , but R-cycles are not considered.	The minimisation of virgin raw materials, water and energy has been piloted at machine, process and company levels.	Production-on-demand allows the company to limit inputs and to reduce outputs , avoiding unnecessary use of raw materials, water and energy.	Circular production scheduling considers also the stocks of supply chain partners .	Production is environmentally sound , which is enabled by close monitoring of the environmental impacts of production processes.

Logistics

Linear value chain	Linearity	Industrial CE piloting	Systemic material management	CE thinking	Full circularity
Logistics	Company has no aim to optimise logistics.	Logistics optimisation pilots are taking place.	In addition to deliveries, logistics covers raw materials and waste.	Linear and reverse logistics are considered with partners . Traceability of products is implemented.	Value chains are localised, and closed loops are implemented. Transparency of products, production and logistics is enabled.

Marketing and sales

Linear value chain	Linearity	Industrial CE piloting	Systemic material management	CE thinking	Full circularity
Marketing and sales	Company has not included CE sustainability views in their marketing activities.	Communication of CE piloting activities is planned as part of strengthening the company's image.	Materials origins, work force and locations are communicated transparently.	Proactive demonstrations of sustainability activities on the environmental, social and economic levels are capitalised.	Product-as-a-service and X-as-a-service approaches are implemented.

Product use

Linear value chain	Linearity	Industrial CE piloting	Systemic material management	CE thinking	Full circularity
Product use	Products are not reused or repaired during their life-cycles.	Pilots are undertaken for reuse and for the recovery of materials from used products.	Production plans are based on an analysis of multisource product usage data.	Understanding customer behaviour and needs enables a prolonged life-cycle, upgrades and repairs to products.	Sharing economy business models provide novel alternatives for product usage.

End of disposal

Linear value chain	Linearity	Industrial CE piloting	Systemic material management	CE thinking	Full circularity
End-of-life	At end-of-life, the product is treated as waste.	Pilots are undertaken that upgrade materials or products for reuse.	Reuse of products, side flows and waste is implemented.	Environmental, social and economic impacts of end-of-life products are known.	The next life-cycle of a product is known, with its environmental, social and economic impacts.

Conclusion



Companies need methods and tools to guide them in their CE transformation strategy and journey.

Without collaboration the higher CE maturity levels cannot be reached

The matrix of CE maturity levels and manufacturing value chain helps companies to proceed towards higher CE maturity levels

Validation of this matrix with DMP pilots that will decrease environmental impact and increase collaboration along the supply chain.

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