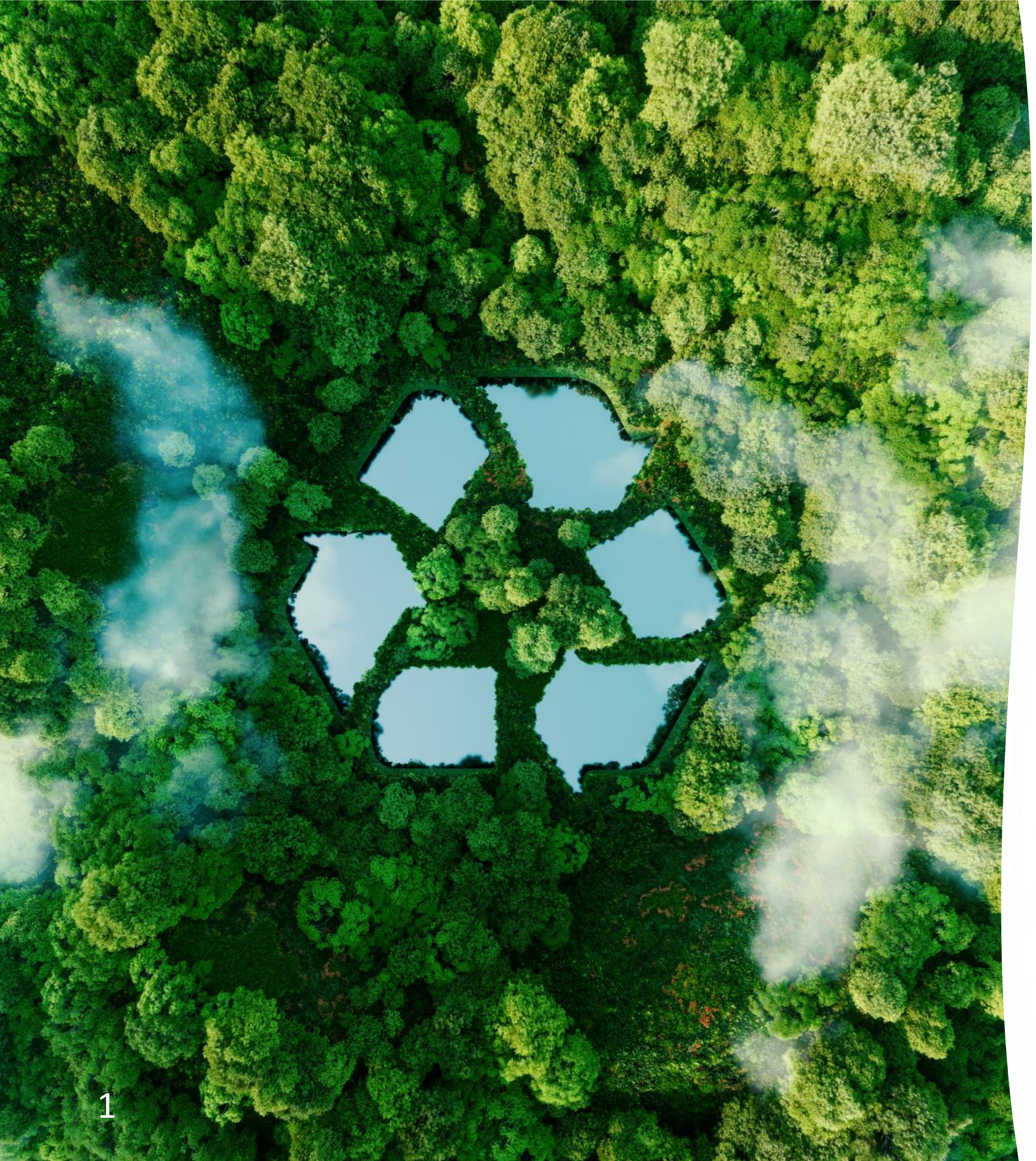

TREASoURcE

TREASoURcE webinar

Challenges, barriers and gaps inhibiting transitioning to Circular Economy

Results and lessons learnt from stakeholder interviews, state-of-the-art and regulatory reviews of TREASoURcE Key Value Chains: plastics, batteries and bio-based side and waste streams

02.02.2023, 13.00-15.30 CET
Microsoft Teams

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TREASoURcE

Bio-based side and waste streams for biogas and circular nutrients

Challenges to circular bioeconomy transition

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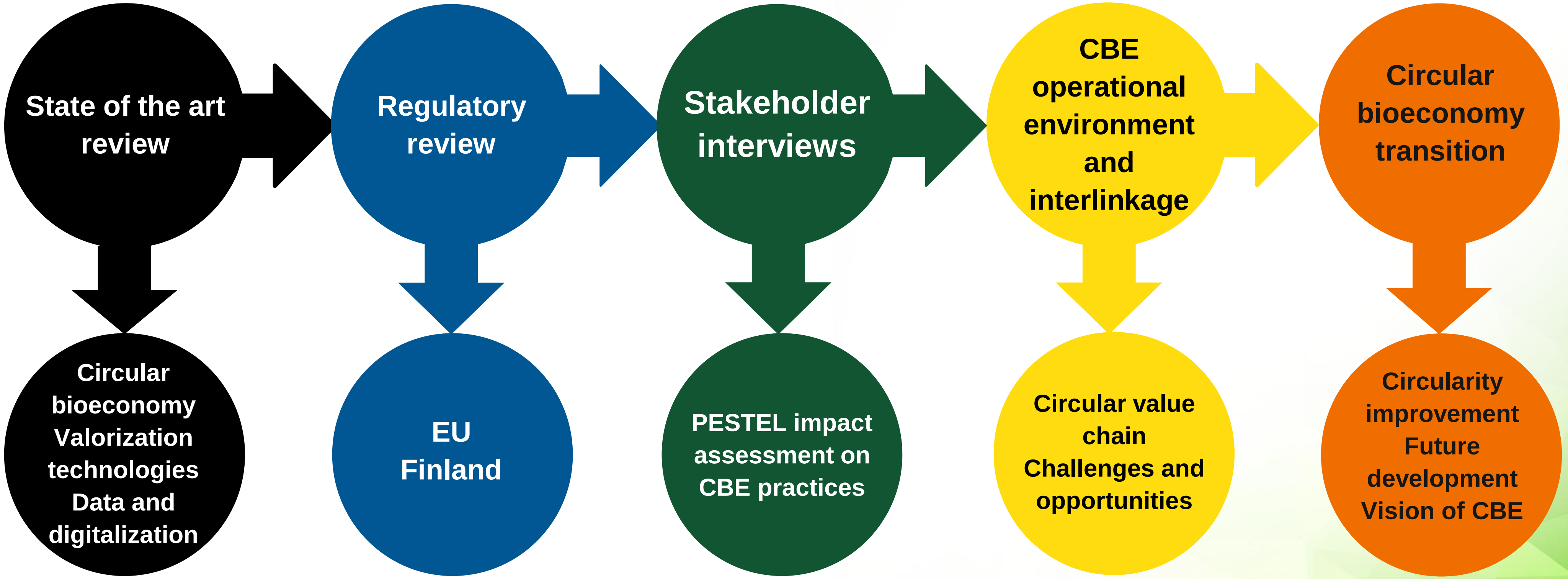
2nd February 2023

Analysis summary:

Literature Review and Case Studies of Circular Bioeconomy Models:
Self-sustaining Circularity – Urban-Rural Symbiosis – Industrial Ecosystem



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Content

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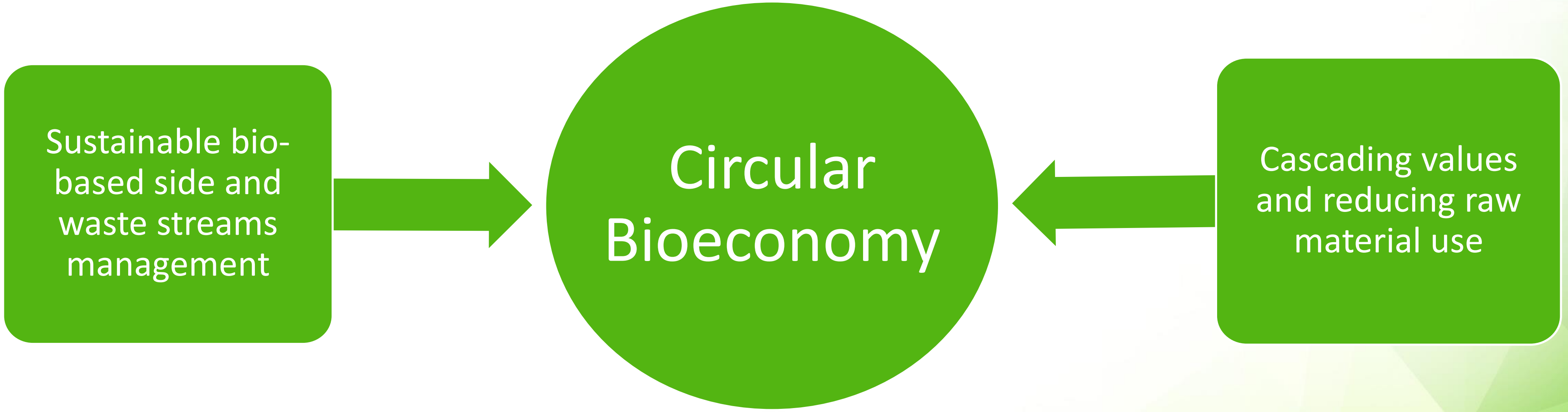
1. Introduction

TREASoURcE

- Bio-based side and waste streams are major resource generation while possessing high nutrient and energy potentials



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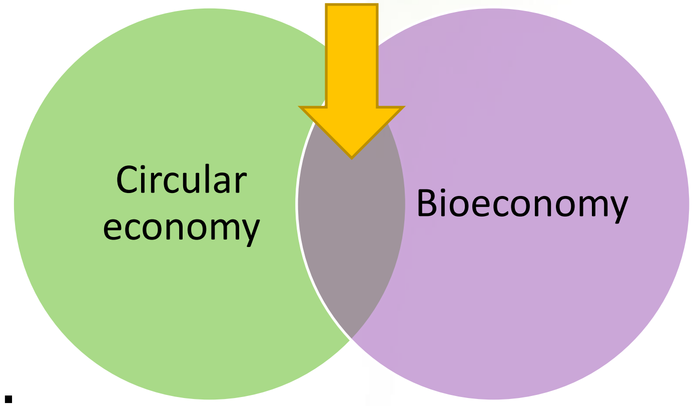
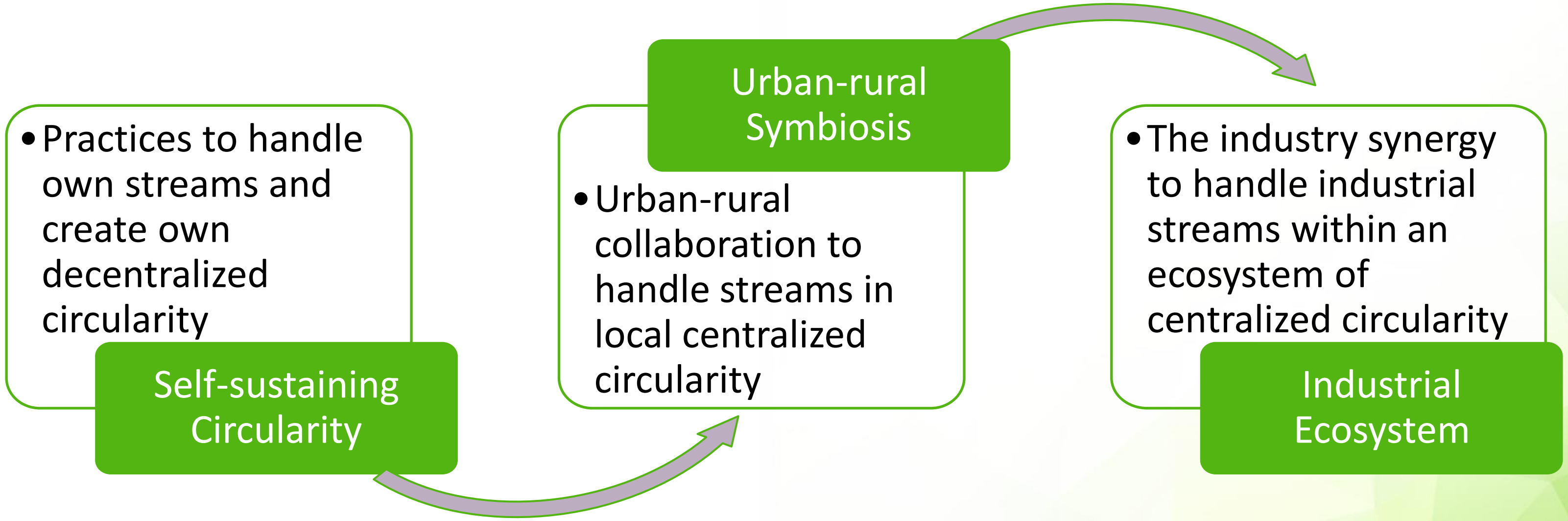
2. Circular bioeconomy

- Concept:



- Operational models:



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Technological review: Valorization technologies Data and Digitalization

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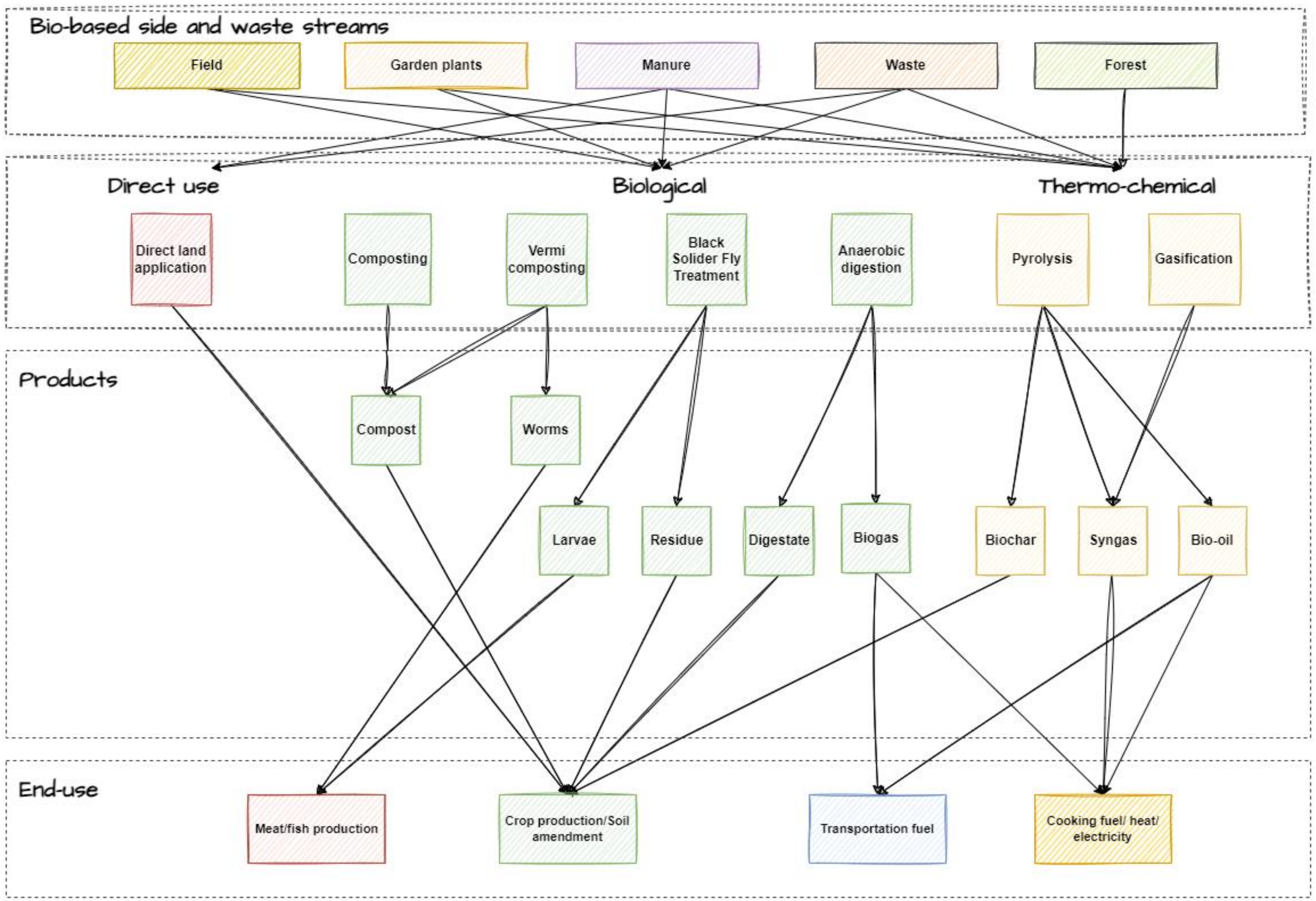
3. Technological review

3.1 Valorization technologies for biogas and circular nutrients



(Figure adapted from Lohri et al. 2017)

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3.1 Valorization – Findings:

- Composting and anaerobic digestion are the traditional, well-developed and widely adopted method in various scale
- Needs to concern about quality of feedstocks in direct land application
- Biological methods require least energy, but long processing time, microbial process control to ensure yield is a challenge
- Thermal method is energy intensive, requires flue gas treatment
- Black solider fly treatment has high potential for industrial application and economic success
- The main challenge is **ensuring product quality, upgrading and removing unwanted substances**
- The scale-up challenge often lays in finance

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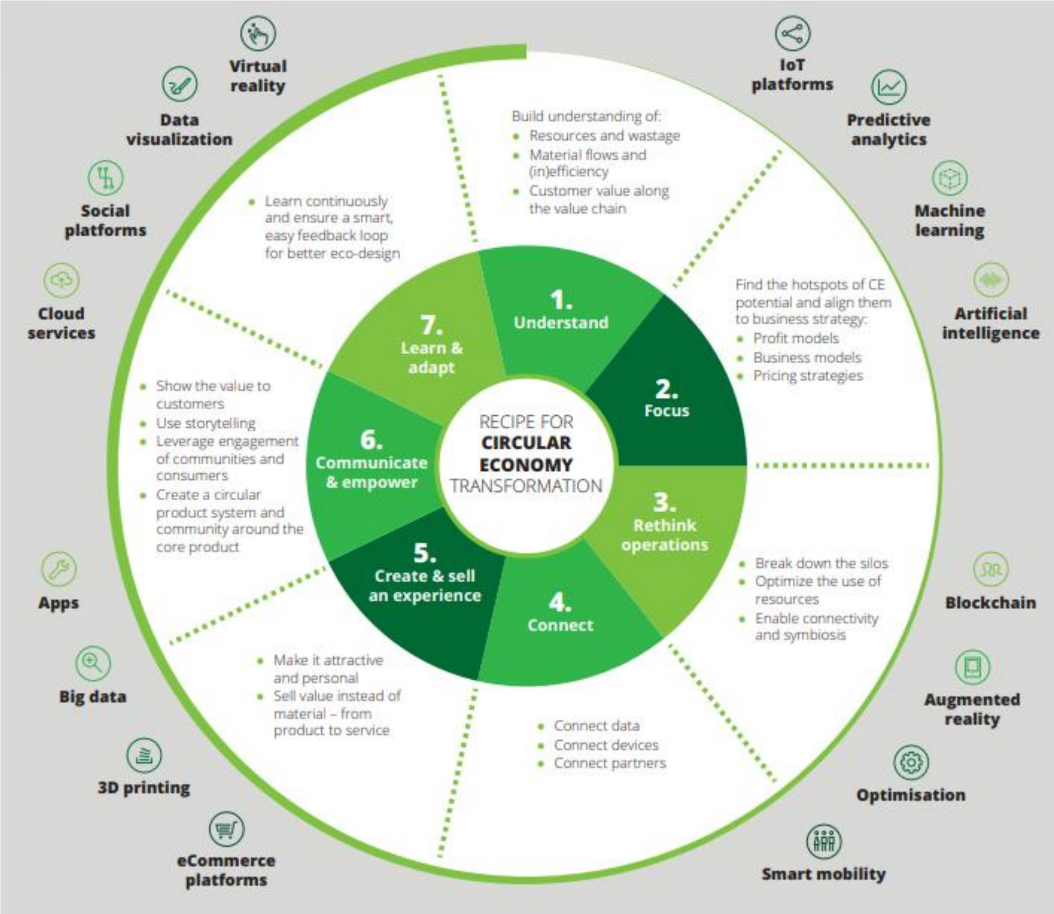
3. Technological review

3.2 Data and Digitalization:

- E-commerce platform
- Smart waste management (Cloud services)
- AI (Sorting, sewage management infrastructure)
- Blockchain (value chain management, digital product passport)



Source: Circular goes digital.pdf (deloitte.com)

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3.2 Data and digitalization - Findings:

- Play crucial role to accelerate circular bioeconomy transition
- Provide transparency, sharing of information and process optimization
- High quality data and digital infrastructure required
- Highly skilled developers and digital ability for users
- Data flow, access, protection and privacy concern is limiting AI ability to learn and make decision
- Ensure data reliability for Blockchain

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Regulatory review:

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4. Regulatory review: Inhibitor

Regulation	Content	Impact
Animal by product (EC 1069/2009) (Urban Agenda for the EU 2020)	The Animal By-Product regulation does not take into account sanitising effects of various manure processing methods	Strict requirements for products derived from animal by products, hampering the placement on the market of bio-waste based digestate
Income and corporate tax (Pantzar & Suljada 2020)	High tax on labour cost for CBE operations	Make the use of raw material cheaper than CBE recovery practices, make CBE unattractive to get people involved
VAT (Pantzar & Suljada 2020)	High VAT (24%) on CBE products	

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4. Regulation - Findings:

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- Not focusing on reducing virgin material usage
- Need to reduce tax and improve incentive for circular bioeconomy practices
- Harmonizing between regulations and standards
- Eco-design labelling for bio-based side and waste streams recovery
- Taking into account technological innovation to boost the recovery of strictly regulated bio-based side and waste streams
- Promoting digitalization in accelerating circular bioeconomy (Eco-design regulation with digital product passport, Finnish Waste Act with Materiaalitori.fi)

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Stakeholder interview:

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5. Methodology

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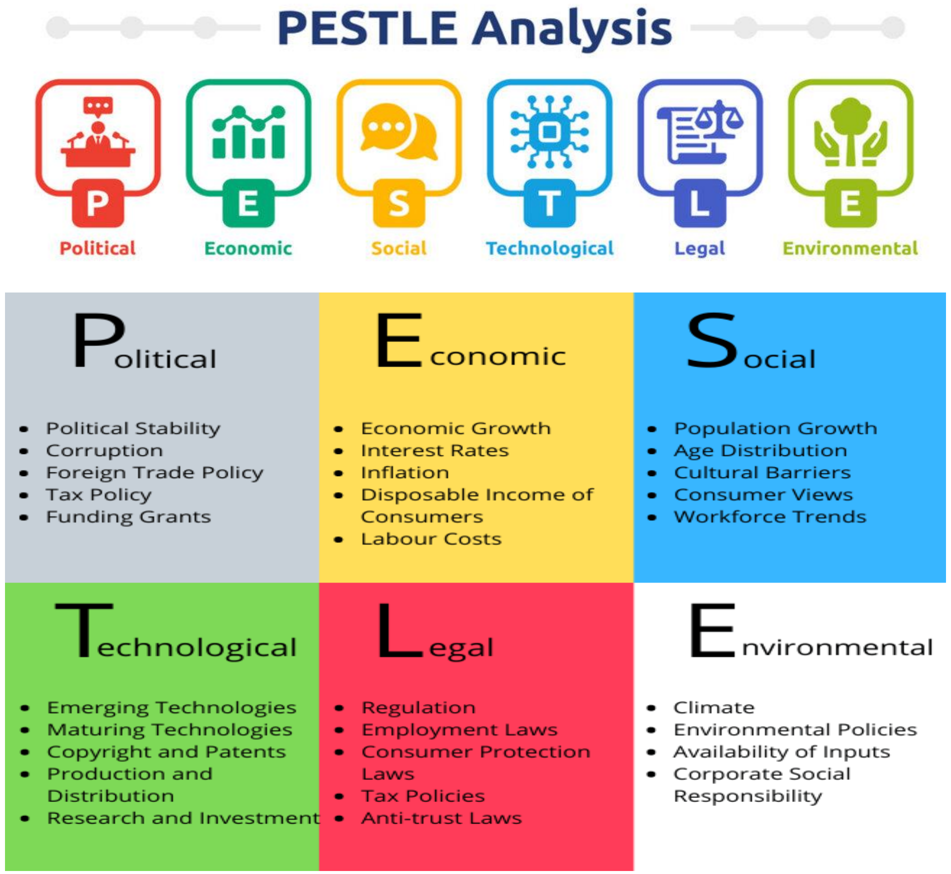
CBE models	Case study	Value chain role
Self-sustaining circularity	HAMK manure hygenization project	1. Company developing Manpas devices
		2. Research and education
Urban-rural symbiosis	Urban-rural collaborative through E-marketplace	3. Marketplace developer
		Primary producer questionnaire
Industrial ecosystem	ECO3 in Nokia	4. CE platform developer
		5. Biogas buyer
		6. Fertilizer producer
		7. Consultancy
		8. Waste collector and Biogas producer
		9. Consultancy
		10. Research and education



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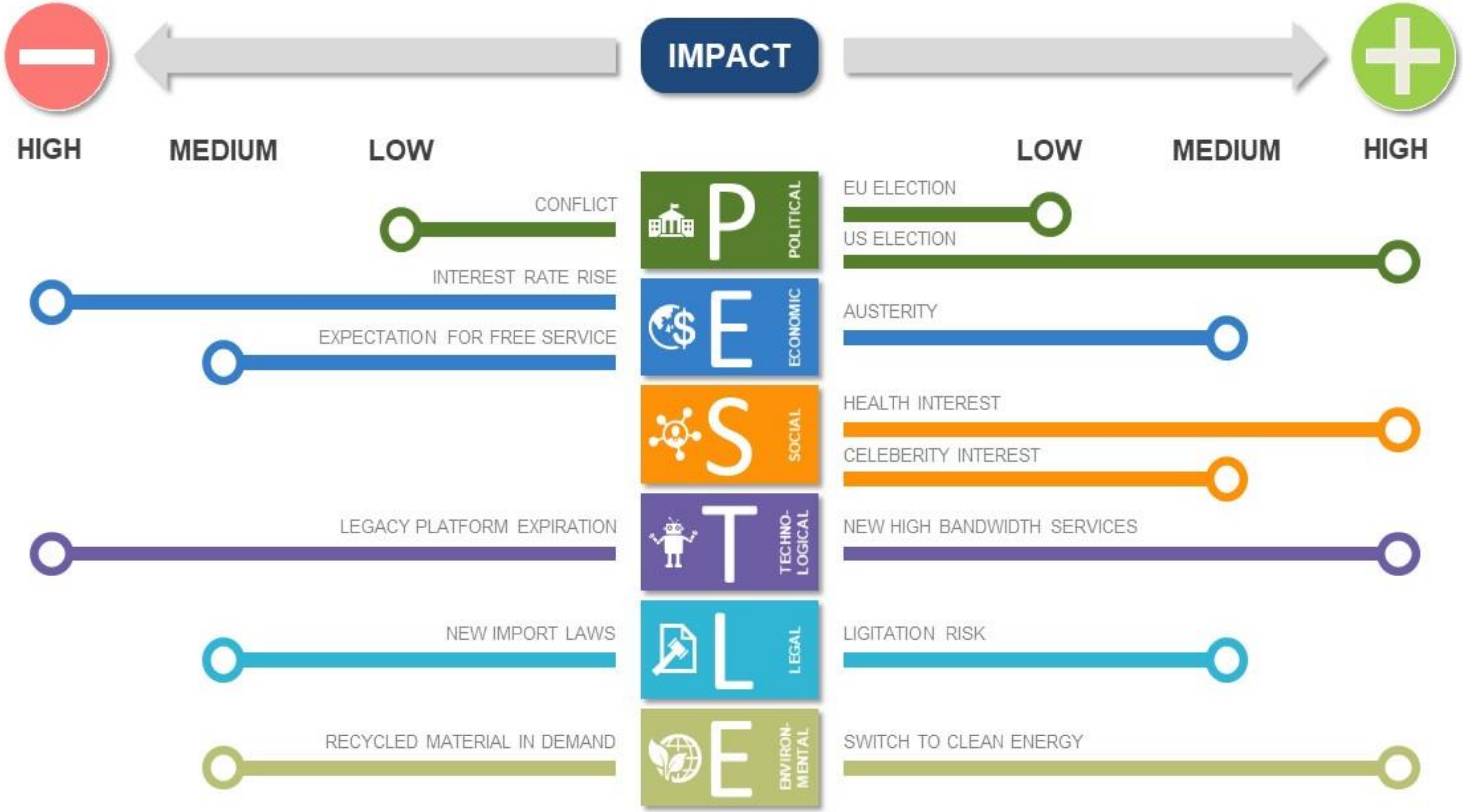
PESTLE IMPACT MAP – POSITIVE & NEGATIVE



Interactive PESTLE impact assessment:

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Webinar participants' impact assessment:

https://forms.office.com/e/DSPXzEZD1J

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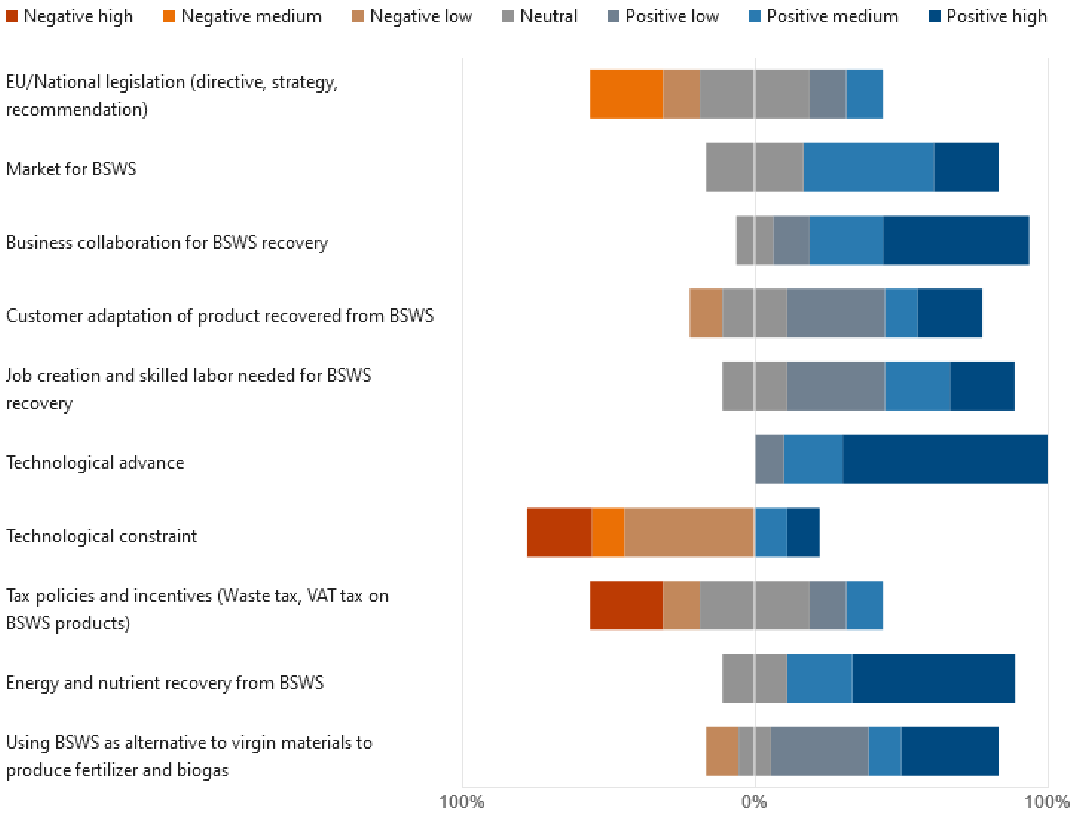
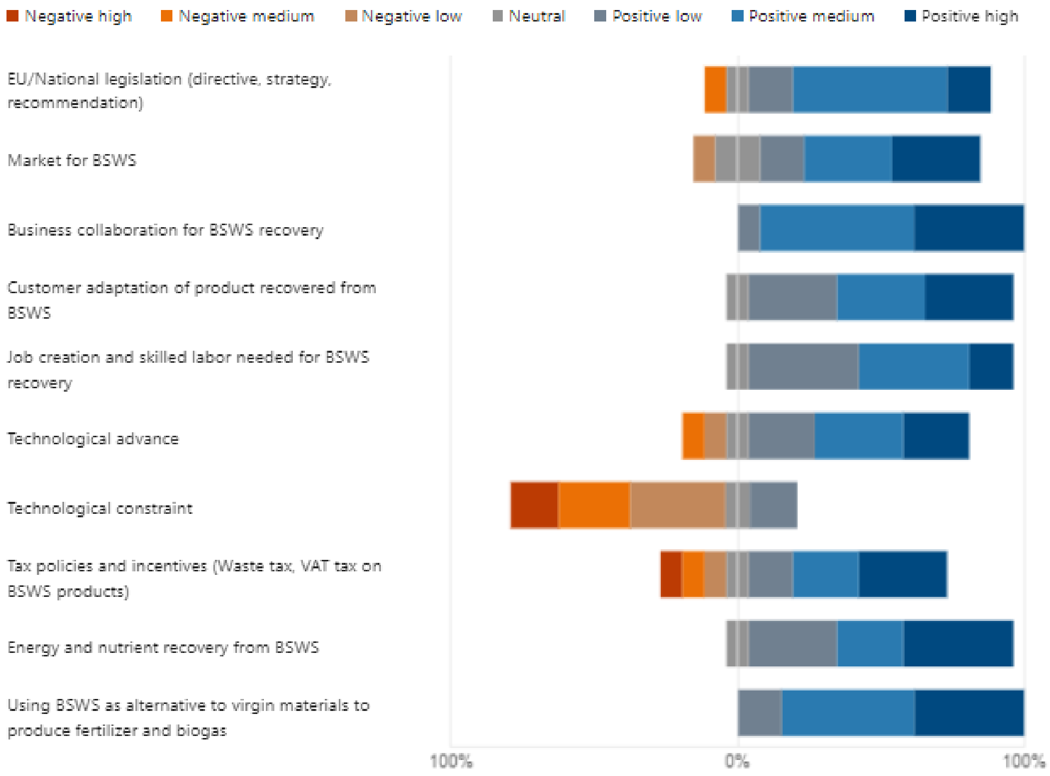
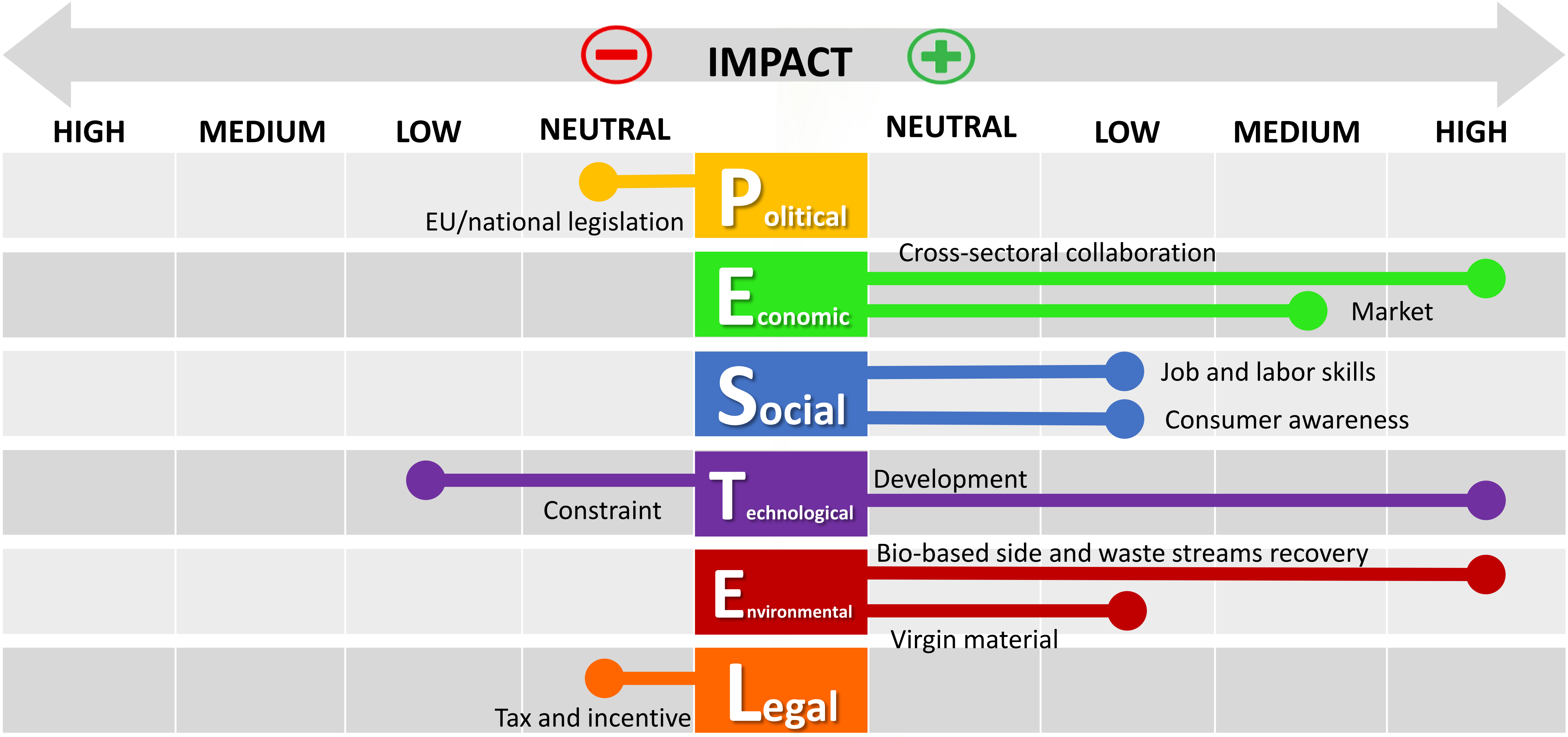
Interviewees (n=10)



Webinar participants



Stakeholders’ assessment result (n=10)



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6.1 Self-sustaining circularity: HAMK manure recovery project

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- A joint project of HAMK to test ManPas manure hygienization device for horse manure recovery
- Small-scale testing: produces about 1.5 m3 of hygienized manure per week
- A quick hygienization method: temperature of the manure is 70°C and the processing time is 1 h (EU by-product regulation)
- Lower the risk of microbe diseases (Eco-li), diminish weed seed
- Turn manure into soil improver and bedding for horse

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PESTLE analysis result: Positive high

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Political	Economic	Social
- Hygenization process follows EU by-product regulation - However, to commercialize manure recovery product will require many permits	- Saving from recovered bedding while safely treat manure - Chance for new business model to sell - Find initial funding challenges	- Customer acceptance is good - Cheap and fast solution, better than burning manure that require chimney emission treatment
- Challenge to fully inactivate the contaminants in short processing time - Still in small scale, need testing in large scale to verify the process and quality of products	- Farmer participating in the experiment get 50% subsidies of the machine	- Bring good impact, hygenized product can replace peat as bedding for animal - If we keep track of animal feed and control manure quality, the product can be used to grow food
Technological	**Legal**	**Environmental**

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6.2 Rural-urban symbiosis: E-marketplace for BSWS

- Circularity from Finland (kiertoasuomesta.fi) developed by MTK
- Improving BSWS circulation and usage
- Connecting BSWS producer and recycler
    - BSWS producers can sell their BSWS and generate additional income
    - BSWS recyclers can find the available BSWS input for their BSWS recovery practices or leave the notices of materials they need
- Resource flow, supply and demand mapping

-> Building plan for new refinery plant

-> Developing business opportunities

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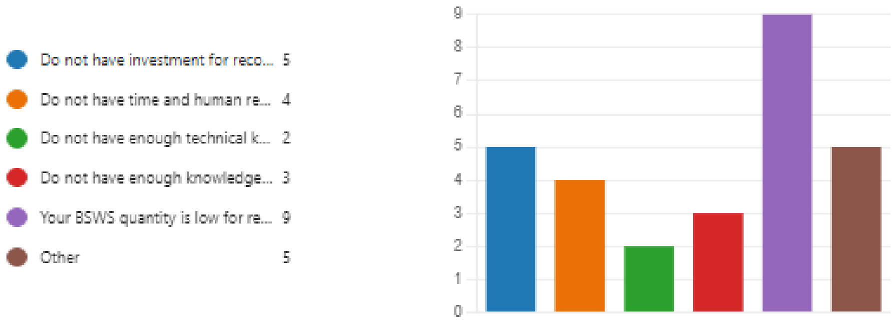
Questionnaire results (n=28)

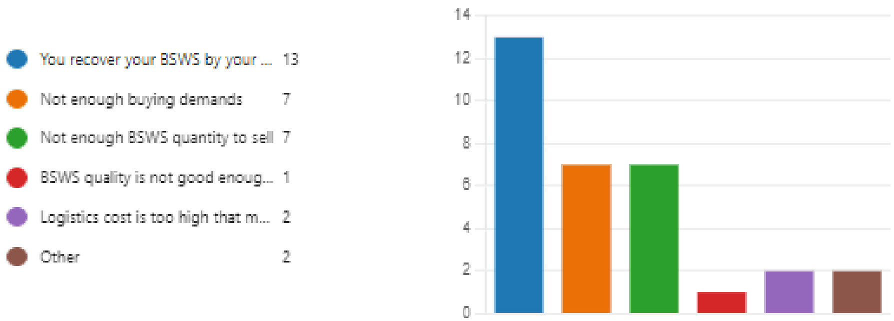
10. If you do not recover your BSWS by your own, what hinder you to do it?

More Details



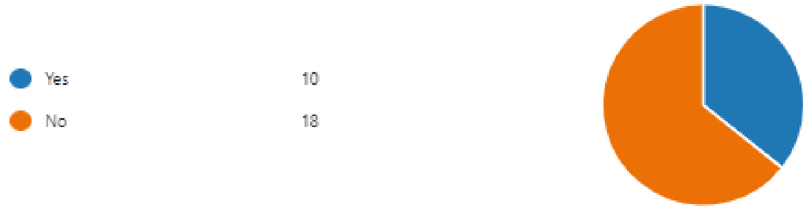
11. If you do not sell your BSWS, what hinder you to do it?

More Details



26. Do you have any hesitancy to use e-marketplace for trading your BSWS?

More Details Insights



27. What are your hesitancies?

More Details

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PESTLE analysis result: Positive low

Political	Economic	Social
- Finnish Waste Act supports the use of e-marketplace (Materiallitori.fi)	- Logistics are the main cost problem in BSWS handling - Industry demand can drive but at the same time, funding to develop new solution is lack	- 54% of questionnaire participants may use the e-marketplace, 18% No and 28% Yes. 34% hesitancy. - Traditional work can be resistance
- Lack of clear disposal guide for BSWS producers - Quantity is low to recover by its own or sell - Unfamiliar with digital system and service fee are the hesitancy to e-marketplace	- Manure can be used to very limited extent in field farming - Tax and cost are too high for small operators to get profit - Slow paper work process	- May cause overexploitation of raw biomass for bioenergy production - Need to foster BSWS to be utilized as raw materials
Technological	**Legal**	**Environmental**

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6.3 Industrial ecosystem: ECO3

- An industrial-scale, multidisciplinary bio- and circular economy business area in Nokia, Finland
- Developed by the City of Nokia and Verte Ltd
- 18 companies within the area
- Boosting nutrient, wood, energy cycles

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PESTLE analysis result: Positive medium

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Political	Economic	Social
- Biogas is supported in renewable energy due to energy security and war crisis, but things can change very fast, drop price	- The market for biogas is raising. However, electricity car is more favourable than biogas car - Market for organic fertilizer is good, but lack of good quality BSWS sources to produce	- Need to integrate circular knowledge into education in all disciplines - Create platform for ecosystem management and sharing of innovation
- Low value of product - Impurity of products and biogas causing major challenges and cost to upgrade - Low quality and quantity of feedstock - Microbial process control	- Taxation and fiscal measure to support circular practices or lower the fossil fuel subsidies are needed - Need to unite regulation between countries	- Positive impact of BSWS recovery can outweigh minor impact and risk of methane leak and plant odor and emission
Technological	**Legal**	**Environmental**

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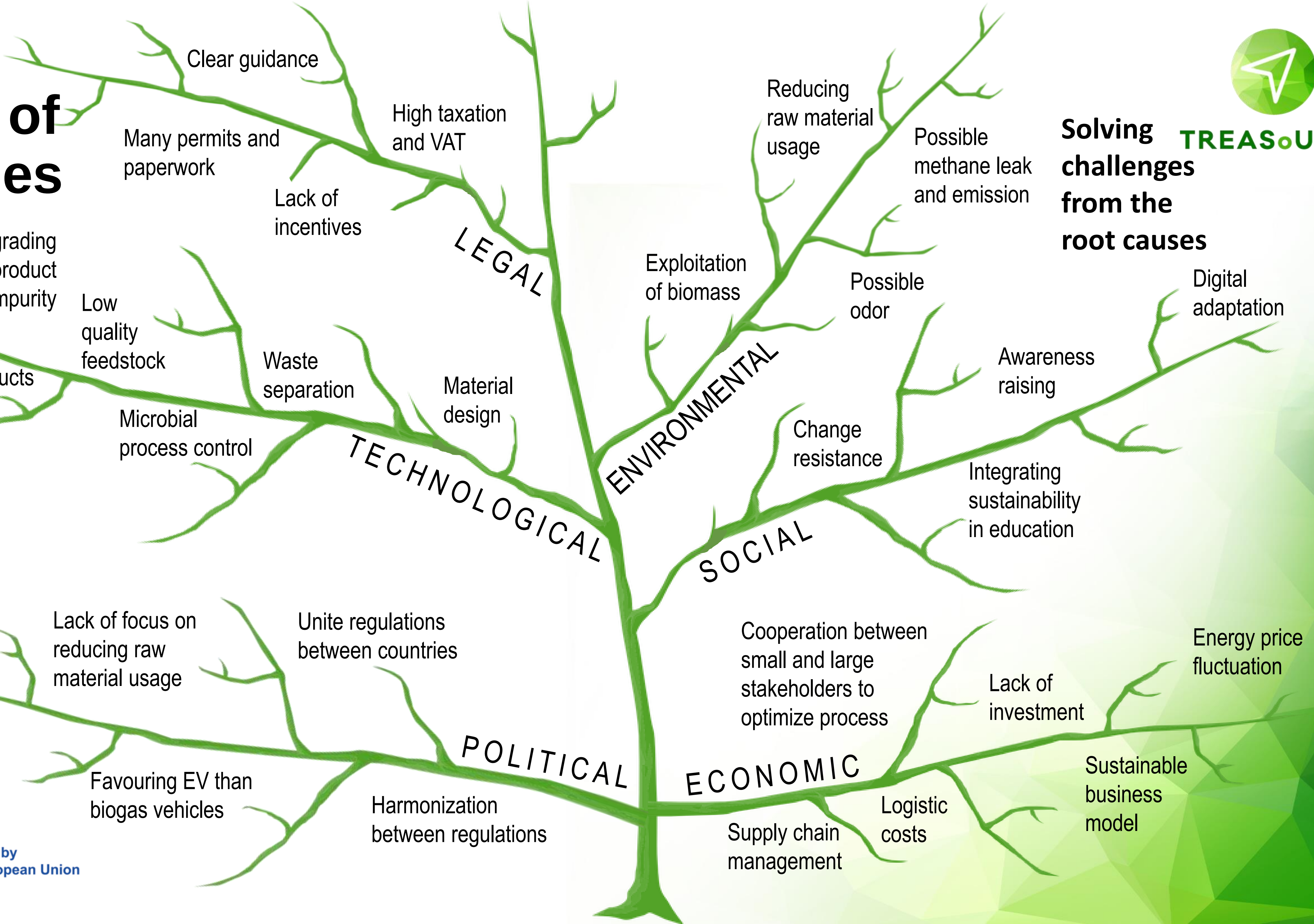
The tree of challenges



Solving challenges from the root causes

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Define how challenges are connected

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7. Lesson learned

- Improve from the **root of tree of challenges** (For technologies, improve from sustainable material design and waste separation to process control and product upgrading and refinery)
- Improve **supply chain**, ensure **product quality and quantity** to **bridge the gap between small and large stakeholders** in rural-urban symbiosis
- **Data and digitalization** can accelerate CBE transition (Digital product passport, smart management, e-marketplace) but challenge is digital adaptation
- **Impactful regulations** can be game changer (New Eco-design Directive, Environmental Tax and Fiscal Reform) but need to unite regulations between countries and take into account innovation to handle strictly regulated BSWS
- **Need to reduce virgin material** extraction and **use BSWS as alternatives**
- Support circularity from self-sustaining to industrial ecosystem, small to large **circular practices**, lack of support of small operators though the impact can be very positive
- **Decentralized solutions** to tackle **logistics** and improve **material circulation**
- **Stakeholder engagement and collaboration** are the key
- **Scale-up** needs **financial and political supports**
- Integrate **circular knowledge** into **education** (construction, manufacturing, design, etc.)

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Thank you!

Comments and Questions?

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Identifying challenges, technology & knowledge gaps related to plastics recycling in circular economy

Master's thesis

VTT/LUT Mikko Myrä

02.02.2023

TREASoURcE

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Content

1. Complexity of circular economy of plastics
2. Research methodology
3. Literature review key findings
4. Interviewee and respondent background
5. Challenges and gaps
6. Key takeaways
7. Questions and answers

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1. Complexity of circular economy of plastics

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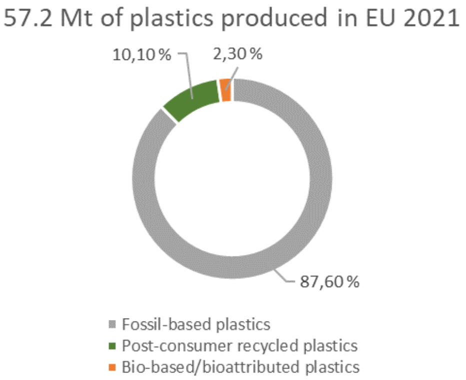
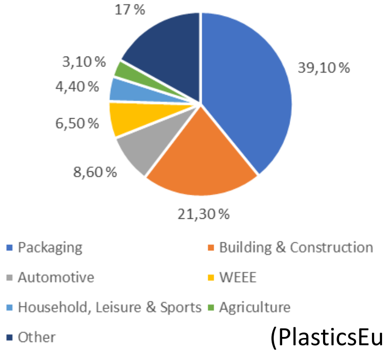
- 57,2 Mt of plastics were produced in Europe
- Over 6 different sectors are using plastic in their products
- Within these sectors there are countless of applications for plastics
- The challenge of transition to circular economy of plastics is diverse spectrum of applications
- Circular economy of plastics is needed to reduce dependance on fossil based raw materials and to reduce the amount of plastic waste in the environment



(PlasticsEurope, 2022)



(PlasticsEurope, 2022)

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2. Research methodology

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- Literature review
  - State-of-the-art review
  - Regulatory review
- Stakeholder interviews
  - Recyclers
  - Developers of recycling machines and systems
  - Organizations advancing circularity of plastics
- Questionnaire
  - Researchers

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3. Literature review key findings

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- Plastic waste streams are very heterogenous further complicating the situation
  - Different plastic types (e.g., PET, PE, PP)
  - Products from various sectors (e.g., Packaging, WEEE, Automotive)
  - Multi-layer/material packaging
  - Hazardous substances (e.g., BFRs)
  - Different contamination levels
- Insufficient and fluctuating material properties of recycled plastic to be used in more demanding applications
- Recycled plastic can be challenging or unattractive choice for product designers compared to virgin plastics
- Advancements in technology development are needed to supply market with more and higher quality recycled plastic and make it more attractive choice for brand owners.

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4. Interviewee Background

8 Interviewees from Europe

Finland (3), Austria (2), Netherlands (1), Italy (1), Belgium (1)

Organization sizes

<50 (3), 250-1000 (3), >1000 (2)

Sectors interviewed

Recyclers

- Waste from Electrical and Electronic Equipment (2), PET bottles (1), Post-consumer plastic packaging (1), Post-consumer plastic waste (1)

Organizations actively advancing circularity of plastics (2)

Developers of recycling machines and systems (1)

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4. Respondent Background

13 Respondents from Europe

Finland (8), Germany (2), Austria (1), Norway (1), Belgium (1).

Organization sizes

<50 (1), 50-249 (1), 250-1000 (3), >1000 (8).

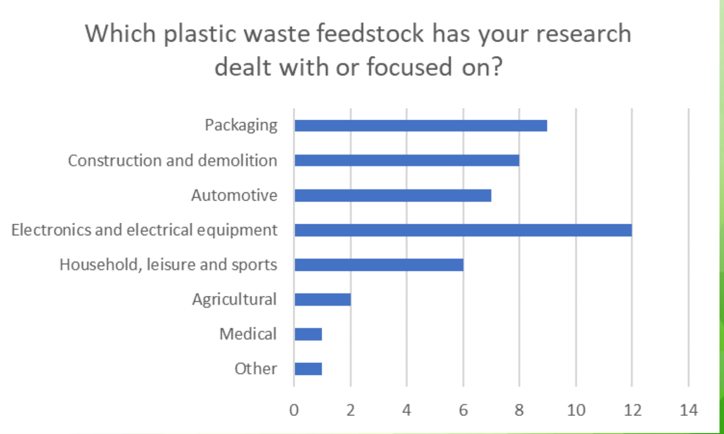
Titles

Researcher or scientist (4)

Senior researcher or scientist (6)

Professor or similar (2)

Civil servant (1)



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5. Challenges and gaps
Collection

- Lack of separate collection
  - No mandatory separate collection of plastics for all households
    - Ease sorting by consumers and businesses

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5. Challenges and gaps
Waste management and its diversity

- Fluctuations in feedstock quality and quantity
    - Specific factors affecting the quality of feedstock negatively mentioned by interviewees:
        - Lack of consumer and business awareness
        - Sorting and washing quality
        - Exceeding the limitation of regulated substances (e.g., BFRs)
        - Humidity
        - Other contaminants and plastic waste that is not appropriate for certain recycling technology.

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5. Challenges and gaps
Waste management and its diversity

- Development in sorting technology
  - Speed, reliability and price
  - Many of the industries operate with old/outdated equipment
- Lack of information on the origin and composition of the feedstock
    - Challenging to identify or detect chemical structures, contaminants and hazardous substances at low levels that are unevenly distributed
- Lack of knowledge on the final use of the recycled material
- Lack of priority to plastic fraction originating from e-waste leads to its contamination

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5. Challenges and gaps
Feedstock acquisition

- Especially in Central Europe there is growing competition to acquire high quality plastic waste
  - In a way a good thing indicating more recycling but in a way interest for worse quality plastic waste is not as high.
    - There is definitely waste with lower quality available

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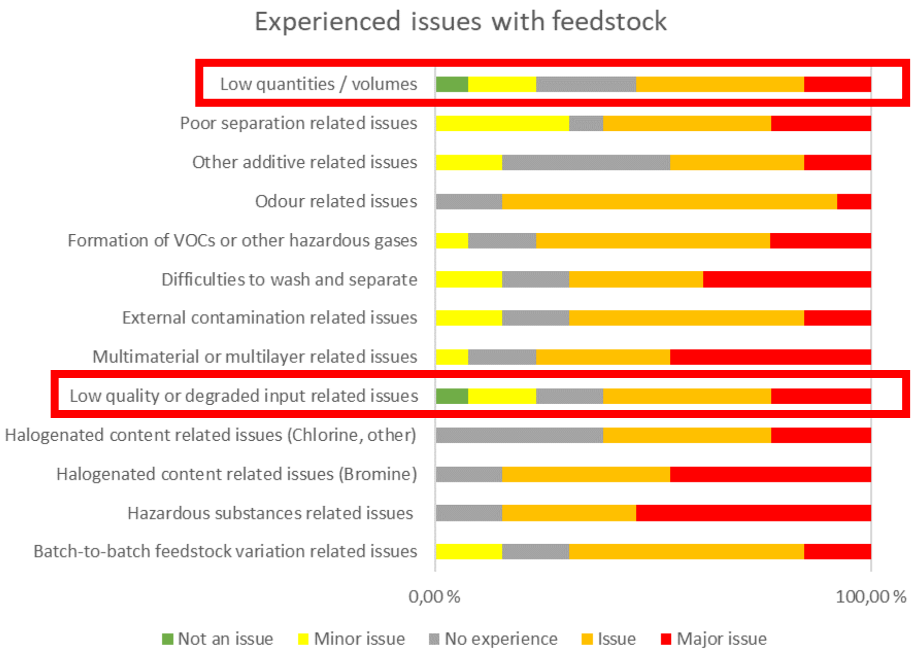
5. Challenges and gaps
Feedstock acquisition

- There is a need for guaranteed stable supply of feedstock in terms of quantity and quality for recyclers
- Also, a need for recycling technologies to handle more fluctuations in quality



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5. Challenges and gaps
Exports

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- Unnecessary exports of waste when local recyclers are not operating on full capacity.
  - A recycling plant in Finland cannot operate on its full potential as a supplier of high quality and well sorted plastic waste is supplying multiple recycling plants from Finland to Europe
- Necessary exports when local recycler don’t have enough capacity
  - Recycling plant in Finland has no capacity to treat all of the plastic waste generated in Finland.

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5. Challenges and gaps
Ownership of the waste

- Uncertainties regarding ownership of the plastic waste
  - The ownership of plastic waste can be fragmented consisting for example in Finland of producer responsibility, municipal waste management and private waste management.
  - Leading into sorting facility being unattractive field to invest, as there might not be certainty for acquisition of enough plastic waste.

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5. Challenges and gaps
Design for recycling

- More design for recycling is needed
  - There are improvements especially in packaging sector, but there is still a lot of room for improvement especially in WEEE sector as the design for recycling is not visible there.
  - Specific challenges discussed by interviewees:
    - Multi-material packaging (e.g., plastic/aluminium packaging).
    - Multi-layer packaging when layers cannot be separated easily.
    - Certain adhesives that are hard to wash off.
    - Carbon black plastics cannot be identified by optical sorters.

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5. Challenges and gaps
Design for recycling in Electrical and electronic equipment

- In WEEE sector the sustainability goals of brands can contradict each other (e.g., Electrical equipment can be designed to last, but then it can be complicated to recycle)
- WEEE recyclers have noticed an increase share of plastics and new polymers in the waste stream that they are not prepared to recycle.

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5. Challenges and gaps
Unawareness or lack of investments by converters, original equipment manufacturers or brand owners

- There still exist some unawareness or lack of trust by converters, original equipment manufacturers and brand owners to increase their uptake of recycled plastic where material properties could be sufficient.
- Correction of old presumptions that recycled plastic cannot be high quality raw material
- Different properties of recycled plastic compared to virgin plastic may require manufacturers to modify their process or redesign or change specifications of their products.
- More, good, unbiased and trustworthy proofs of environmental benefits of the use of recycled plastic are needed.

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5. Challenges and gaps
Acceptance of recycled plastic

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- Experts views sometimes differ from the policies of authorities regarding the acceptance of recycled plastic in certain applications.
- Stakeholders especially in WEEE sector were discussing the challenge of the lack of communication with authorities regarding the possibilities and limitations of limiting certain substances.
  - Fast changes and reductions of threshold limits for certain substances can be very challenging or impossible for recycling industries to adopt to the required changes.
  - Changes of regulations are hard to predict which can cause hold backs in technology development and investments designed for certain threshold limits.

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5. Challenges and gaps
Acceptance of recycled plastic

TREASoURcE

- More focus on high-quality recycling to enable its use in more demanding applications
- Clear product standards for recycled plastic
    - Facilitate its processability in existing production lines that are originally designed for virgin plastics
- There is a challenge of guaranteeing no presence of substances of concern in recycled plastic to enable its use in new products with out any risks.
- Data and documentation on the quality of upcycled plastic should be more transparent

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5. Challenges and gaps
Price of recycled plastic vs. virgin plastic

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- Lack of willingness to pay more for recycled plastic
  - As mandates for PET bottles are taking place in 2025, many of the companies are targeting only the minimum amount of recycled PET content.
- Energy crisis has further increased the price of recycled plastic as the process is energy intensive.
- There are no substantial incentives to choose recycled plastics over virgin plastics as a raw material

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5. Challenges and gaps
Lack of capacity

- Achieving European recycling target for 2025 is not likely to be achieved. (50% of plastic packaging waste)
  - 2030 recycling target (55 % of plastic packaging waste) might be achieved but requires a lot of effort across the whole value chain.
  - Optimization of densely populated areas is needed.
  - Some of the existing recycling plants are not operating on their full potential that also needs to be optimized
- More recycling and sorting capacity is needed overall.
  - Current sorting industry is either inefficient, not providing sufficiently separated and stable waste flow or the capacity is lacking.
  - Recycling industry should focus first on production of high-quality recycled plastic and then more capacity should be targeted

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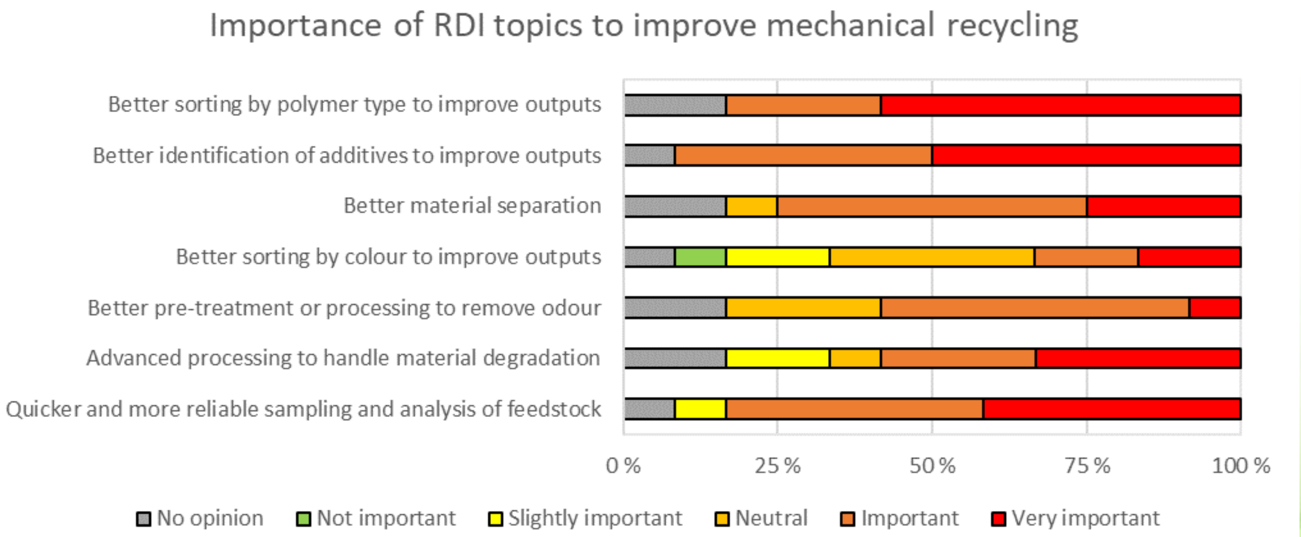
5. Challenges and gaps
Mechanical recycling



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5. Challenges and gaps
Chemical recycling

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- Chemical recycling is needed to compliment mechanical recycling
  - Treating waste fractions that are not suitable or when the high output quality cannot be achieved by mechanical recycling.
- Chemical recycling specific challenges
  - Highly energy intensive
  - Material losses
  - Higher environmental footprint
  - High investment costs
  - Often high capacity is required
  - Complex process

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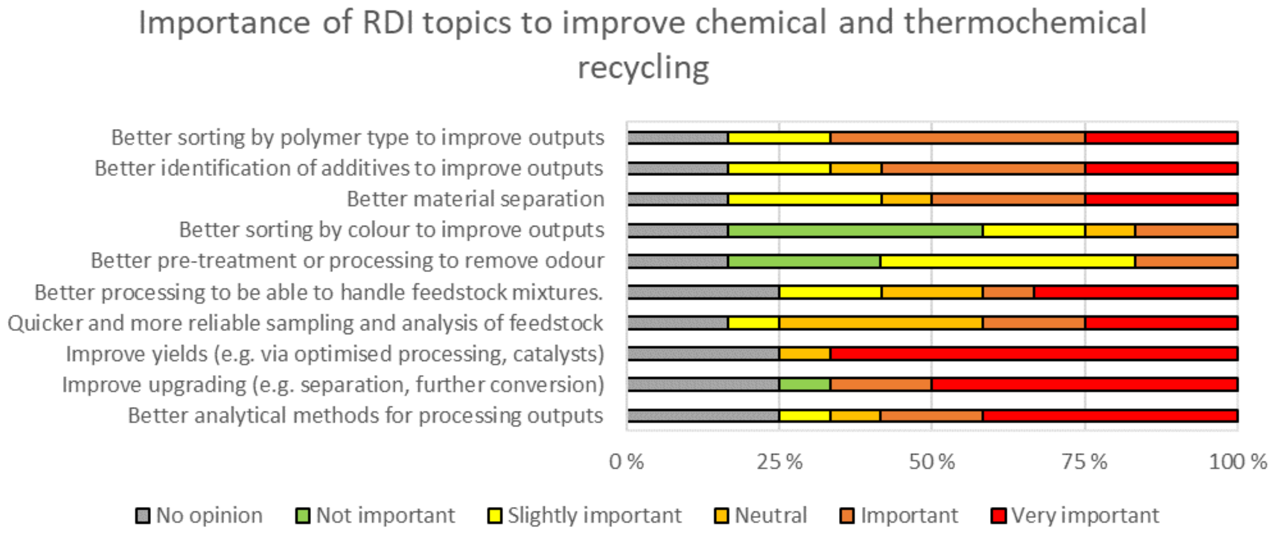
5. Challenges and gaps Chemical recycling



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5. Challenges and gaps
Balance of mechanical and chemical recycling

- Methods to prevent feedstock suitable for mechanical recycling used for chemical recycling are needed
  - Guidelines for the feedstock use in chemical recycling
  - Development in mechanical recycling to treat more challenging waste
  - Development in chemical recycling to treat the most challenging plastic waste.

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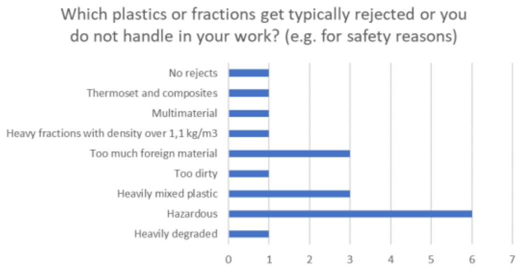
5. Challenges and gaps
Rejects or currently non-recycled plastics

- No utilization of rejects or other non-recycled plastic waste
  - Development in sorting and pre-treatment
  - Development on better identification on the past use and hazardous substances
  - Lack of collected volume of some currently non-recycled to incentives their treatment.
  - Not enough technologies to treat some of the most problematic waste fractions



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5. Challenges and gaps
Regulation gaps

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- Regulations have highly focused on separate collection, but mixed waste has not been considered as much despite containing a big amount of under-utilized plastic waste.
- Recognition of chemical recycling in regulations is limited despite that there are operating chemical recycling plants.
- More attention to non-packaging sectors is needed.
  - More general regulation for plastic waste affecting all sectors would be beneficiary.
  - By focusing more on other sectors, similar improvements could be achieved as in plastic packaging sector and overall improving the plastic waste problem.

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5. Challenges and gaps
Policies

- Lack of clear rules for using recycled plastic
- Current recycling targets don’t differentiate down- and upcycling
- More mandates on recyclate content are needed for increasing the demand especially if uptake will not increase enough naturally
- Not enough EPR schemes for products to incentives designing of more recyclable products

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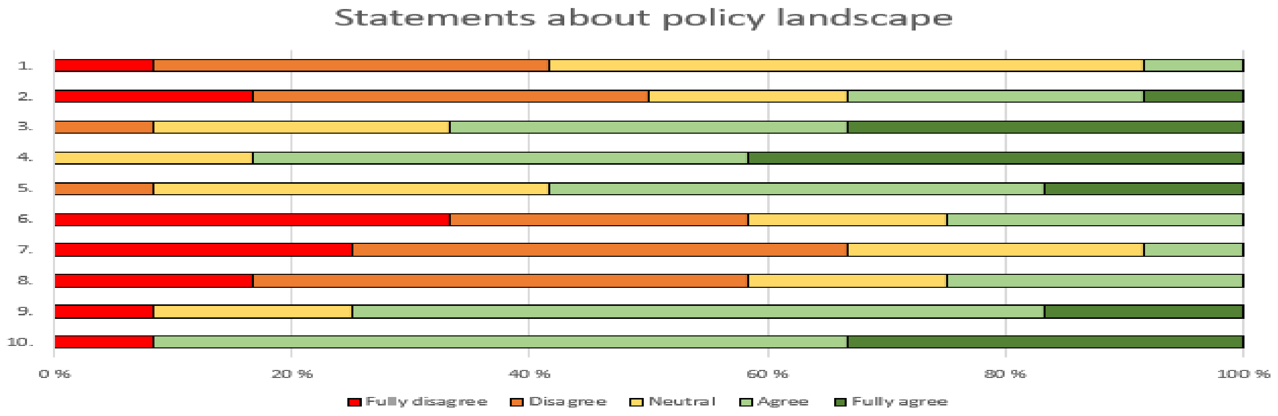
5. Challenges and gaps
Policies

1. Regulations related to plastic recycling and circularity are clear.
2. There are enough (policy) incentives to increase the recycling rates.
3. Regulations mainly target the packaging sector at the moment.
4. Regulations should target other sectors as well.
5. There should be more goals in EU across sectors on mandates* on recyclate use (* requirement by law to have cartain share of recyclates in products)
6. There are enough regulatory actions and social pressure across plastics value chains to transition to circular economy.
7. There is enough easily understandable guidance and supportive documents available to understand the regulations affecting recycling and circular plastics.
8. There are enough targets for recycling rates for sectors using plastics.
9. Separate collection targets are needed for different plastic waste categories.
10. There should be separate targets for producing high-quality recyclate.



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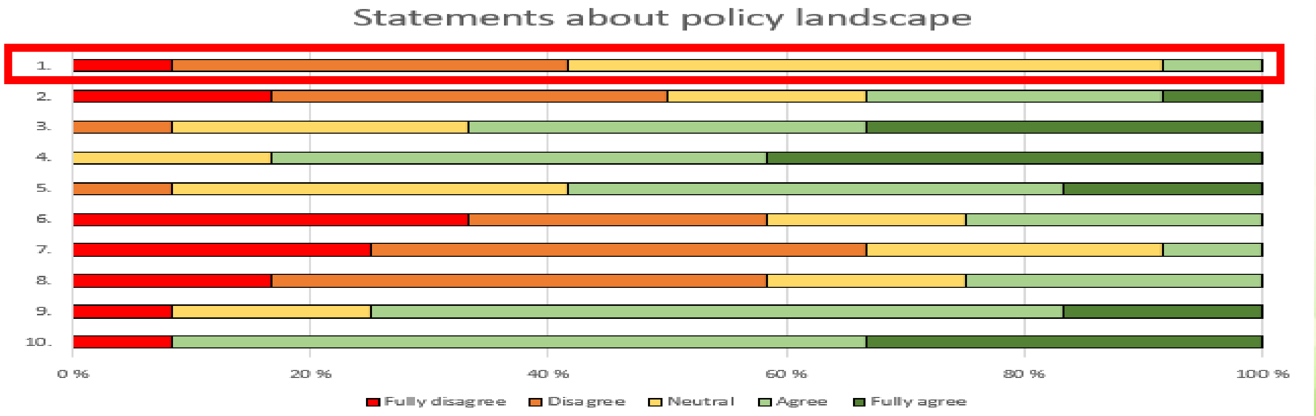

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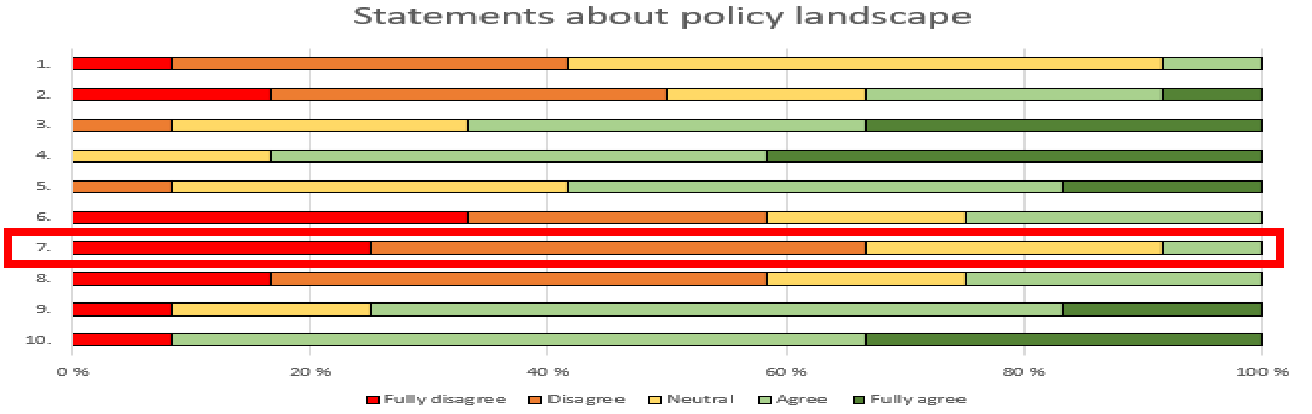

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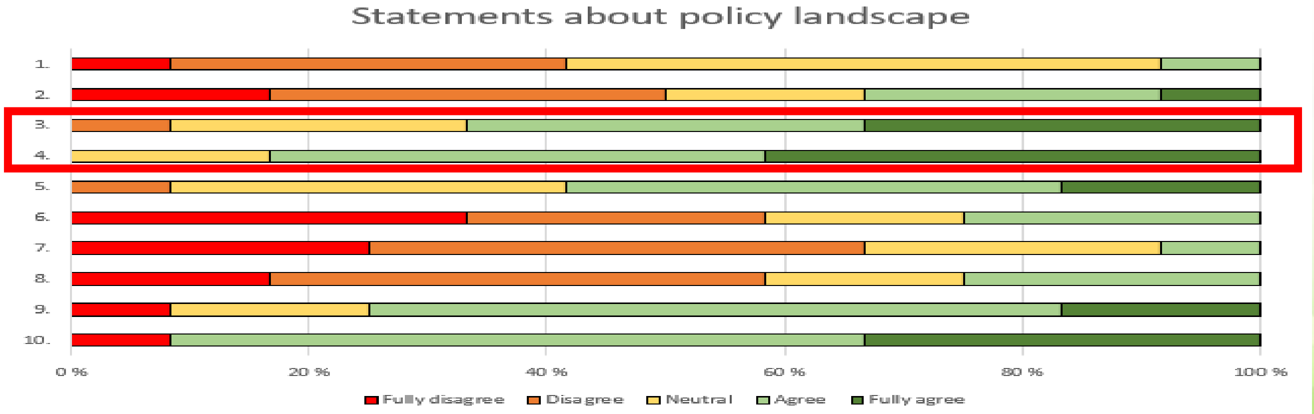

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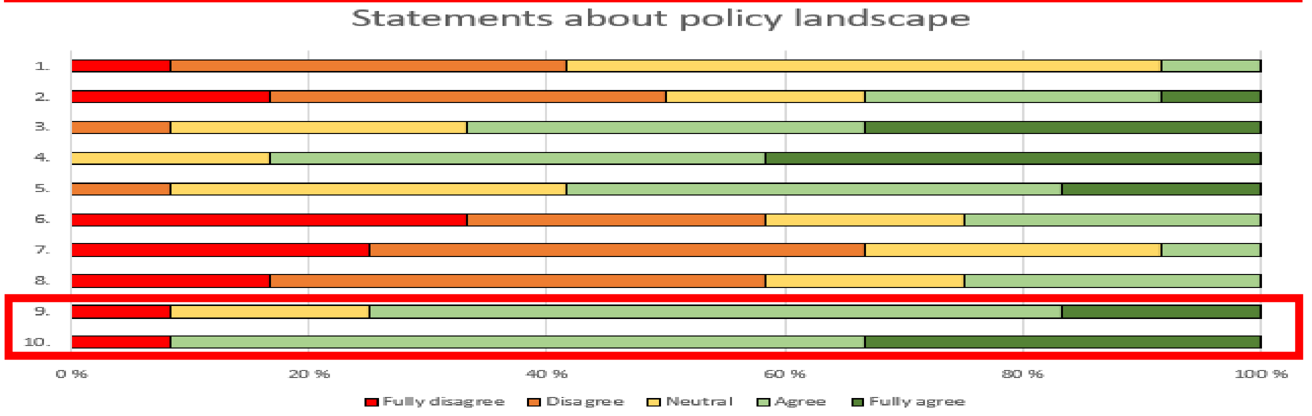

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6. Key takeaways

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- Challenges across plastic value chain have been identified, which depicts the scale and complexity of plastic value chains.
- Challenges and gaps can be categorized into
  - Feedstock acquisition and its quality
  - Recycled plastic and its uptake
  - Technology: sorting, identification and recycling
  - Regulations
- A key takeaway is that every stage of the life-cycle has impacts on the future stages.
  - There is no one major challenge, but multiple sometimes very application-dependent issues.
  - Effort across every stage of the plastics life-cycle is required

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Questions and answers ☺

Thank you!

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Challenges and barriers to repurpose electric vehicle batteries for energy storage applications

Nina McDougall
Master’s Thesis Worker at VTT
Advanced Energy Solutions at Aalto University
2.2.2023

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Contents

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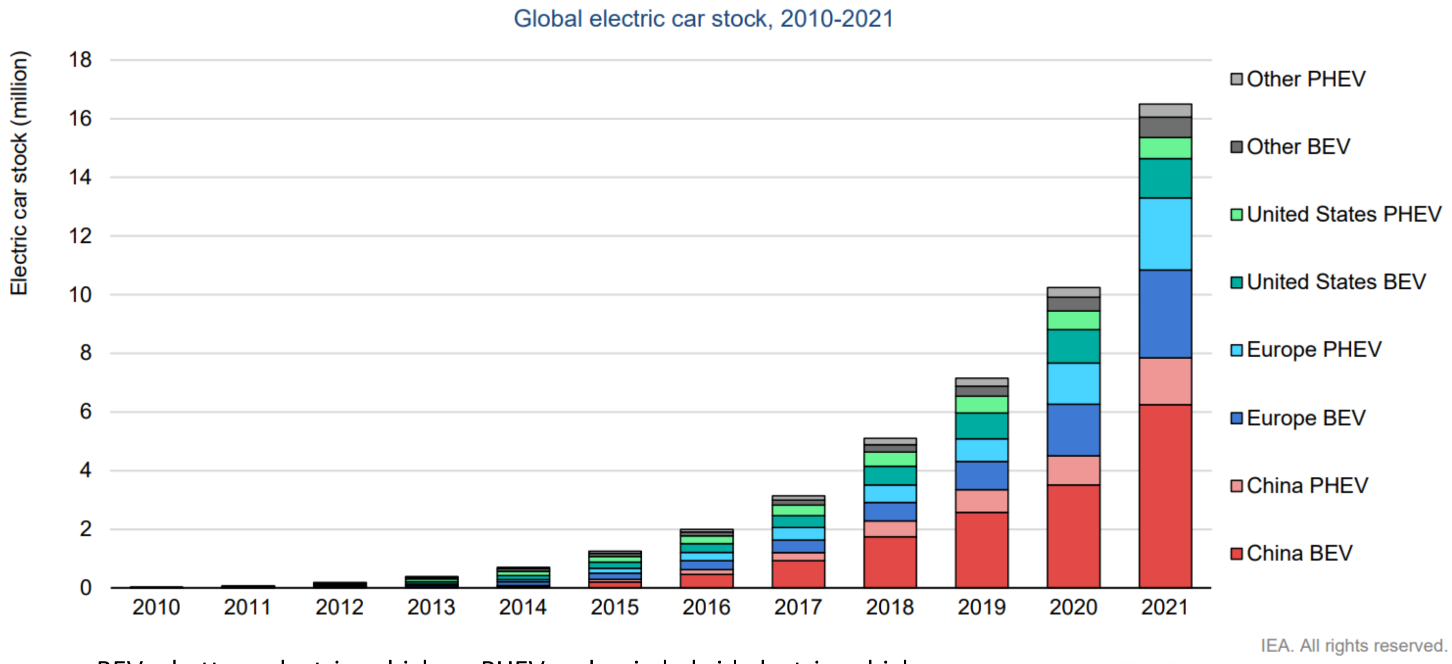
Background

Over 16.5 million electric cars were on the road in 2021, a tripling in just three years



BEV = battery electric vehicle PHEV = plug-in hybrid electric vehicle

- The global electric vehicle (EV) fleet is growing rapidly
- Although this transition is desired to curb climate change, a new challenge arises
- Modern EVs are powered by lithium-ion batteries (LIBs), which must be managed sustainably once reaching end-of-life (EOL)

➢ What should we do with EOL electric vehicle batteries (EVBs)?

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Figure from Global EV Outlook 2022 (IEA)

Current situation

- The current EU regulatory framework (Batteries Directive) requires that **only 50%** of the average weight **of an EVB is recycled**, after which the remains can be disposed of in landfills or by incineration
- The present EVB value chain is still very **linear**, and it has **untapped circular potential**

Figure adapted from: https://data.europa.eu/doi/10.2760/6060

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Recycling – a lower-level circular strategy

Circular economy ↑ Increasing circularity — Linear economy

Smarter product use and manufacture	R0 Refuse	Make product redundant: abandon function or use different product
	R1 Rethink	Make product use more intensive: sharing or multifunctional products
	R2 Reduce	Consume less through efficient product manufacturing
Extend lifespan of product and its parts	R3 Reuse	Reuse of functioning discarded product by another consumer
	R4 Repair	Repair and maintenance of defects to original function
	R5 Refurbish	Restore and update old product
	R6 Remanufacture	Use parts in a new product with the same function
	R7 Repurpose	Use products or parts in a new product with a different function
Useful application of materials	R8 Recycle	Process materials to obtain the same or lower quality
	R9 Recover	Incineration of materials with energy recovery

- Recycling is currently regarded as the main strategy for managing EOL EVBs
- However, there are still significant **material losses** in the recycling processes, which is not sustainable in the long run
- For instance, despite being considered a critical raw material, **lithium is hardly recovered** in the EU due to its high cost compared to primary supplies

➢ What would be a better way to manage EOL EVBs?

Figure adapted from: Potting J, Hekkert M, Worrell E, Hanemaaijer A. Circular economy: measuring innovation in the product chain. The Hague: Agency PNA, 2017.

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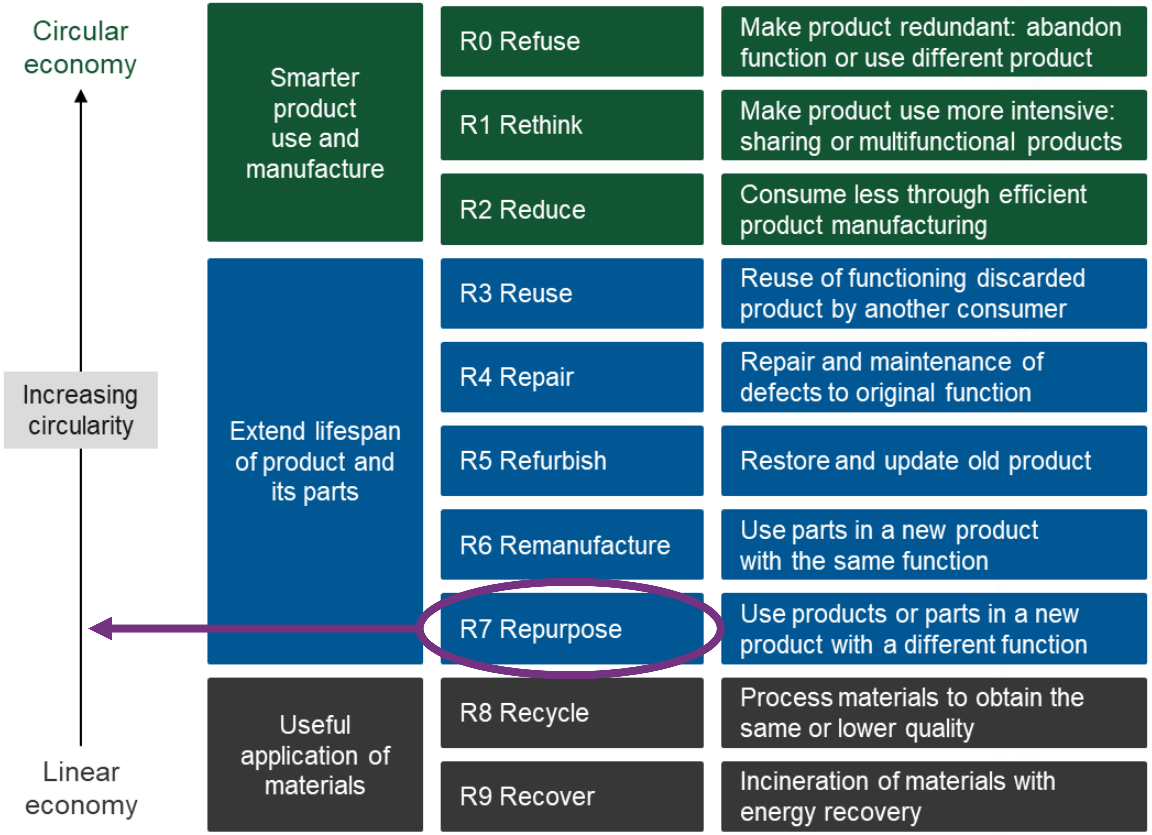
Repurposing – a higher-level circular strategy



- In general, a higher-level circular strategy results in greater environmental benefits

➢ So, what are the benefits of repurposing EOL EVBs for energy storage applications?

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Figure adapted from: Potting J, Hekkert M, Worrell E, Hanemaaijer A. Circular economy: measuring innovation in the product chain. The Hague: Agency PNA, 2017.

Motivation – benefits of repurposing EVBs

Results in reduced carbon footprint and energy use

Helps supply the growing demand for battery storage

Provides the mining industry more time to establish new mines

Gives additional time to develop more efficient recycling processes

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Research objectives and methodology

- The objective was to seek answers to the research questions:
  - What kind of regulatory environment does EU legislation and standards create for repurposing operations?
  - What are the key challenges and barriers for repurposing operations?
  - What actions and measures could support repurposing operations?
- The research methodology was semi-structured interviews

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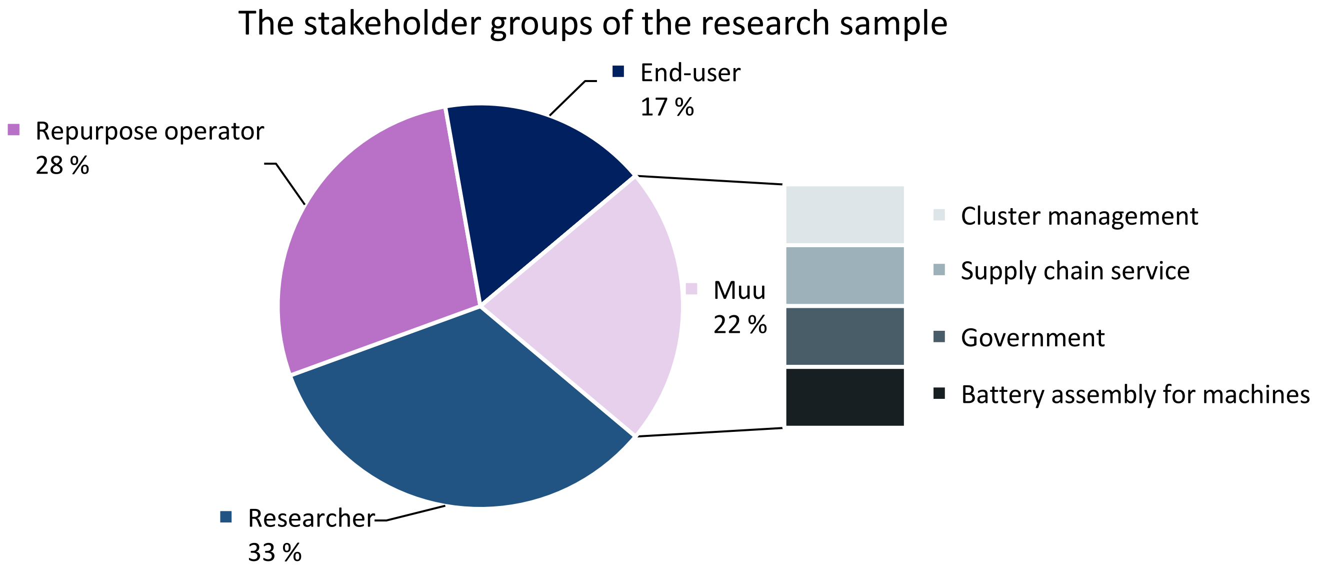
Research participants

- A total of **18 interviews** were conducted, of which 14 were one-on-one, while the other four sessions had two interviewees participating simultaneously
- The **22 participants** were from four countries; 12 from **Finland**, seven from **Norway**, two from **Germany**, and one from **Sweden**



Research findings

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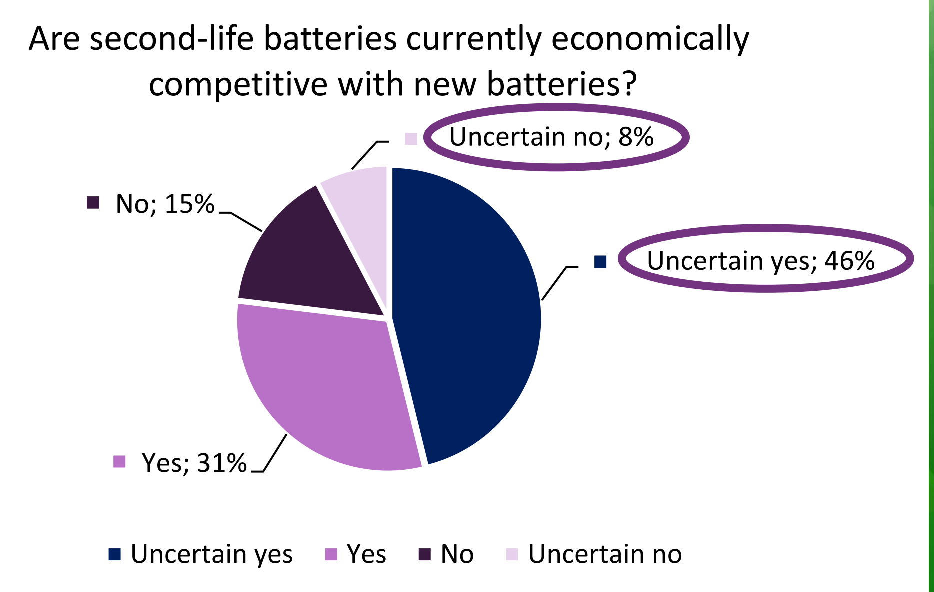
Uncertain economic viability of second-life batteries

- There was a strong consensus that the **sales price** is **the decisive factor** when choosing a battery
  - If the sales price of second-life batteries (SLBs) is the same as that of new batteries, new batteries are usually chosen
  - There were **two exceptions**: considering climate goals, and if the price difference is small, SLBs could be chosen instead of new batteries
- Some participants further considered that **SLBs need to have** a clear **cost advantage**, e.g., 25-50% cheaper than new batteries
- The **economic competitiveness of SLBs is still uncertain** and **case-dependent**

➢ **Proposed solutions**: tax removal, tax rebates, incentives, and paying for carbon footprint

"No one wants to pay the same price for SLBs, which are not manufactured and optimized for the storage application if you can get a new battery that is optimized for the application for the same price."



Second-life batteries = repurposed batteries

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Low availability of electric vehicle batteries

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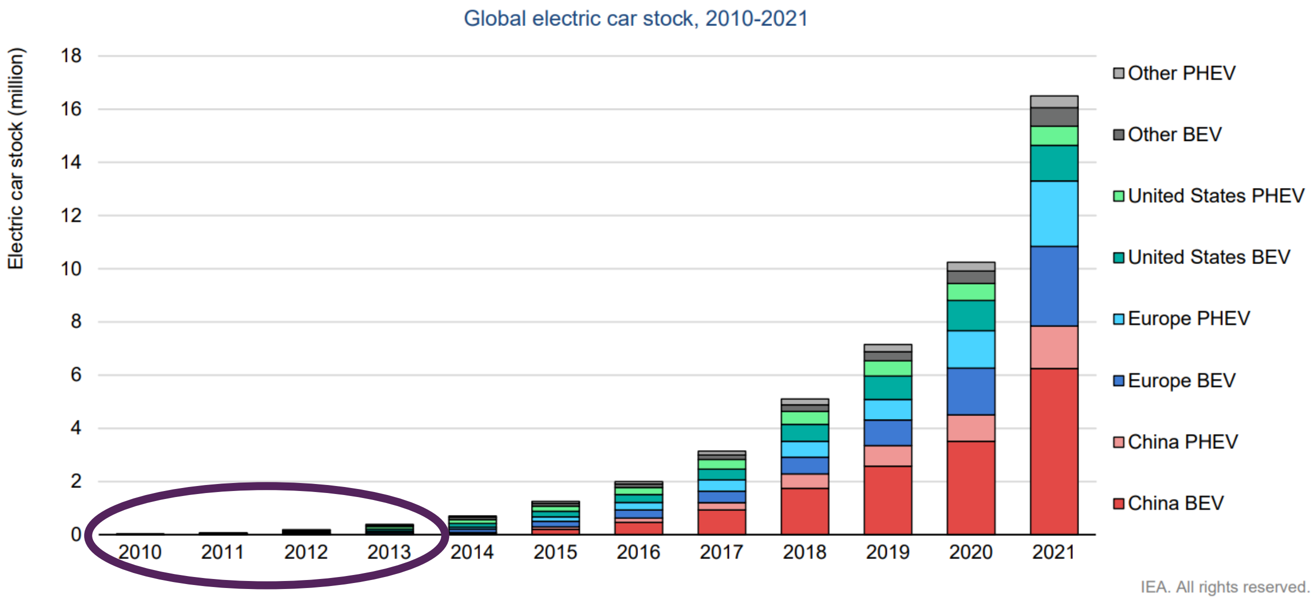
- The **low availability of EOL EVBs** is currently one of **the biggest challenges** for repurposing
- This can be explained by **the novelty of EVs**, which have become common only in recent years and, by the rather **long lifetime of EVBs**
- ➢ Participants expected **EOL EVB volumes** to **increase** in the future
- Another reason for the low availability is that **car manufacturers want** their **EVBs back**

"Our biggest problem is having enough batteries to complete our projects."

"The scarcity of used EVBs now, but the amount will increase in the future."

"Car manufacturers are not excited that old batteries are in circulation. If accidents happen it could negatively affect their brand image."



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Lack of information

- Historical **battery information exists**, but it is **not easily available**, because car manufacturers are often reluctant to provide it
- Repurposing operators typically **aim to access the battery management system (BMS)**, which includes relevant information of the EVB. However, accessing the BMS is **challenging** as there is **no common interface**.
- **Without** historical battery **information**, many **assessment procedures** become **more challenging**

➢ The lack of information **increases the workload**, which directly **affects the sales price of SLBs**

➢ Proposed solutions:
  - Battery passport and access to BMS data, introduced by the EU Battery Regulation
  - Blockchain tracking tool
  - Paying the car manufacturer to provide data

“There is always an information gap that comes from the battery manufacturer, all information is not generally available.”

“The main problem we face is the connection to the BMS. There is no standard connection interface for batteries, so each battery module needs a specifically designed plug.”

“Performance evaluation is challenging because there is no way to know how the battery will degrade if we don’t have historical data”

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Electric vehicle battery designs

- Most technical challenges in repurposing stem from **EVBs** that are **not designed for a second-life**
- Technical challenges relate to the mismatch of mechanical shape, battery chemistries, voltage, and C-rates
- These **mismatches are manageable**. The challenge is more related to the **additional costs** to solve these mismatches, which directly **affect** the **sales price** of the **SLB**.
- The **variability of EVB designs** makes it **difficult to automate** the repurposing process
- Manually repurposed SLBs face a **price competition** with new batteries manufactured automatically
- There are also **new** types of **EVB designs** that could **prevent repurposing**

➢ Proposed solutions:
  - Manufacturers should consider second life in the design phase
  - Legislation should encourage EVB designs to be reusable
  - The EU should promote the standardization of EVB designs

“SLBs are probably not economically competitive with new batteries due to the extra cost of cooling, special mechanical structures, special cabling, and high C-rating compared to many demands in the market.”

“Automation would be nice, but there are too many variables to make it work.”

“In the new Tesla Model Y structural battery pack 4680 […] cells are glued to the car’s frame. Second-life is not considered in the design phase as the car likely needs to be recycled as a whole, because it is difficult to remove the battery. In the worst case, if this design becomes popular, second-life applications can be prevented.”

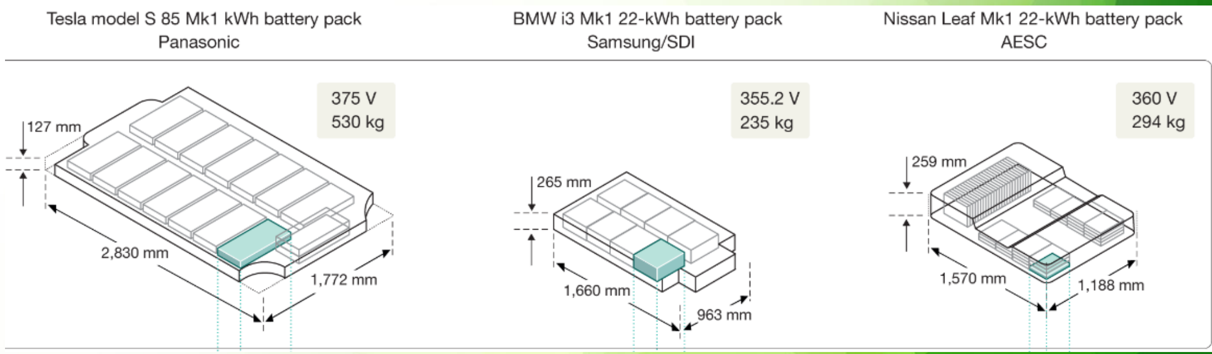

Figure reprinted by permission from: https://doi.org/10.1038/s41586-019-1682-5

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Safety concerns

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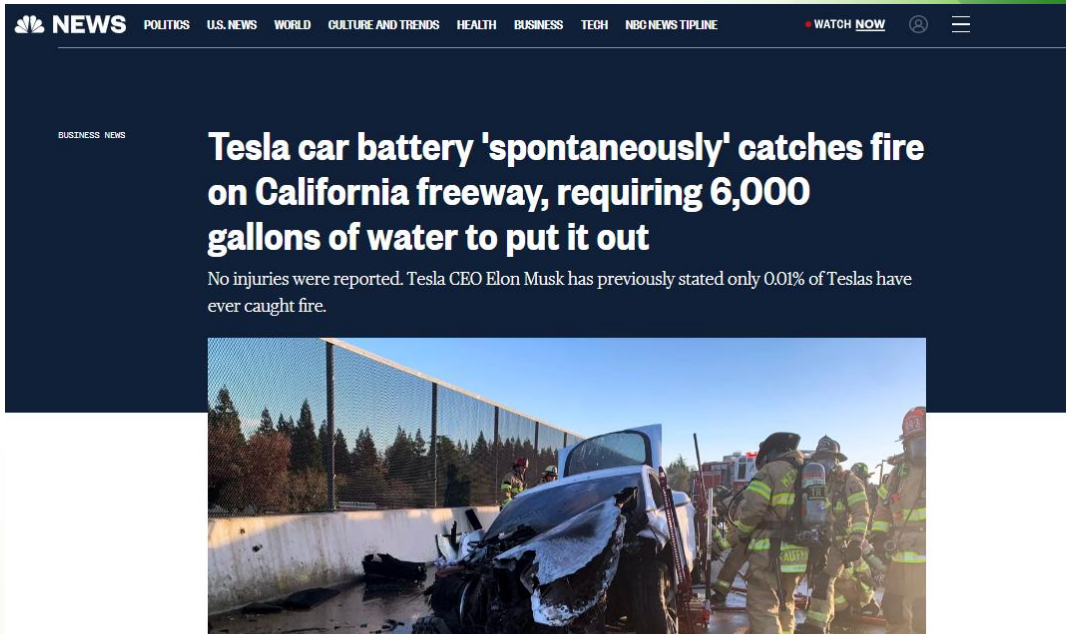
- The safety aspects were considered as one of the main areas of focus for repurposing, because **the risk of safety-endangering phenomena increases with degraded EVBs**
- The **reputation of SLBs** could be **ruined by accidents**
- As an exception, two participants considered that the safety of SLBs is on par with new batteries
- ➢ Various solutions were proposed to ensure the safety of SLBs:
  - Sensors to detect thermal runaway
  - Control and management systems with automatic shutdown
  - Extinguishing systems integrated in SLBs
  - Advanced fault detection systems
  - Local control for internet outages
  - Self-healing methods
  - Cloud service monitoring
- The **risk of fire** was perceived as the **main concern of consumers**
- ➢ Possible solutions:
  - Placing the SLBs outside, in a separate room, or in a fireproofed room
  - Discussing safety matters with consumers
  - Leasing an SLB could be less of a concern than buying an SLB

“The battery is already old, safety problems might occur more likely, e.g., thermal runaway”

“Safety issues are the biggest problems of all. Reputation [of SLBs] could suffer, which would ruin the business opportunity and lead to the direct recycling of EOL EVBs.”

“Customers are most concern about fire safety”

“Accidents have occurred even with new batteries, how will the safety of SLBs be ensured?”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BUSINESS NEWS

Tesla car battery 'spontaneously' catches fire on California freeway, requiring 6,000 gallons of water to put it out

No injuries were reported. Tesla CEO Elon Musk has previously stated only 0.01% of Teslas have ever caught fire.

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Regulatory challenges

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- The **current regulatory environment** is practically non-existent due to a lack of standards and regulations
- Anyone can currently repurpose EVBs, a lot of **do-it-yourself** (DIY) **projects** are occurring that could also **ruin the reputation of SLBs**
- The **extended producer responsibility** of EVBs was also seen as a **possible challenge** for repurposing operations.

“The lack of standards and regulations is causing dangerous situations. People are assembling batteries in their basements. There is no law prohibiting this kind of activity.”

“The producer responsibility side, if the producers pay for the recycling, they have the right to the battery when it reaches the end of its life cycle. How to ensure [the repurposing] step before recycling?”

- As for the **upcoming regulatory environment**, the **recycling targets** introduced by the EU Battery Regulation were a **controversial** topic
- Some considered the **recycling targets** as negative for repurposing as they **could steer EVBs to recycling**
- Alternatively, repurposing was seen as a possible way for the car manufacturers to **avoid** the **recycling targets and fees**
- It was also noted that the recovered content in new batteries does not need to originate from batteries

“The EU Battery Regulation’s recycling targets are the biggest threat to the second-life industry. All batteries must/might undergo recycling to meet these recycling targets.”

“If the manufacturers can avoid these [recycling] targets by sending the batteries to companies like us for second-life applications, it could be very helpful. We offer auto companies a solution to sell their batteries to us rather than pay for recycling.”

“The recycled material in the new batteries does not have to be from an old battery.”

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Competition with recycling

- **Recycling frees valuable metals** from older battery technology, which can be used **to manufacture new, more efficient batteries**
- There is a lot of **development in recycling**, and it was seen as more **easily scalable to mass production**
  - These could potentially lead to **recycling being cheaper than repurposing**
- **Tesla's new EVB design** also pushes in the direction of recycling
- Metal prices also affect recycling; **high metal prices encourage recovering** valuable metals
  - Recyclers might compete for EOL EVBs

"The technical properties of batteries change faster than the batteries wear out in use. The technology of a ten years old EVB is very old compared to new batteries, so it could make more sense to recycle."

"Recycling is being developed a lot and it will probably become cheaper."

"The increase in the price of metals encourages the recovery of materials that were not recovered before."

"If recyclers would pay more for EOL EVB than repurposing operators, it could affect business by making the price of SLBs very high."

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Consumer preferences

- Even with a significant cost advantage, **not all consumers would** choose **SLBs**, because consumers often **prefer new products** over old ones
- Consumer preferences are understandable, especially in the case of SLBs, which have a **shorter lifetime** and **increased safety risks**
- The reluctance of consumers to buy old products can **reduce demand** and challenge the repurposing business

“The masses of consumers prefer new materials compared to old ones.”

“There is always a bias towards new products as they are bound to last longer, have cheaper on-going costs, and are less likely to fail.”

“There is a greater worry about used products compared to new products.”

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Key takeaways

- The **economic competitiveness of SLBs** is **most important**
  - ➢ All costs factors in repurposing should be minimized
- The **reluctance of car manufacturers** to provide historical battery information is **hindering repurposing**
  - ➢ More collaboration is needed
- **EVB designs** that could prevent repurposing **need to be addressed**
  - ➢ EVB designs should be reusable
- **Safety is of great importance;** accidents can ruin the reputation of SLBs
  - ➢ Adequate safety measures must be in place
  - ➢ Dangerous DIY projects should be prevented
- Transitioning to circular economy requires **a change in mindset** and in **consumption habits**
  - ➢ Products do not always have to be the newest and most efficient

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Questions and answers

Feedback and comments on the webinar presentation

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