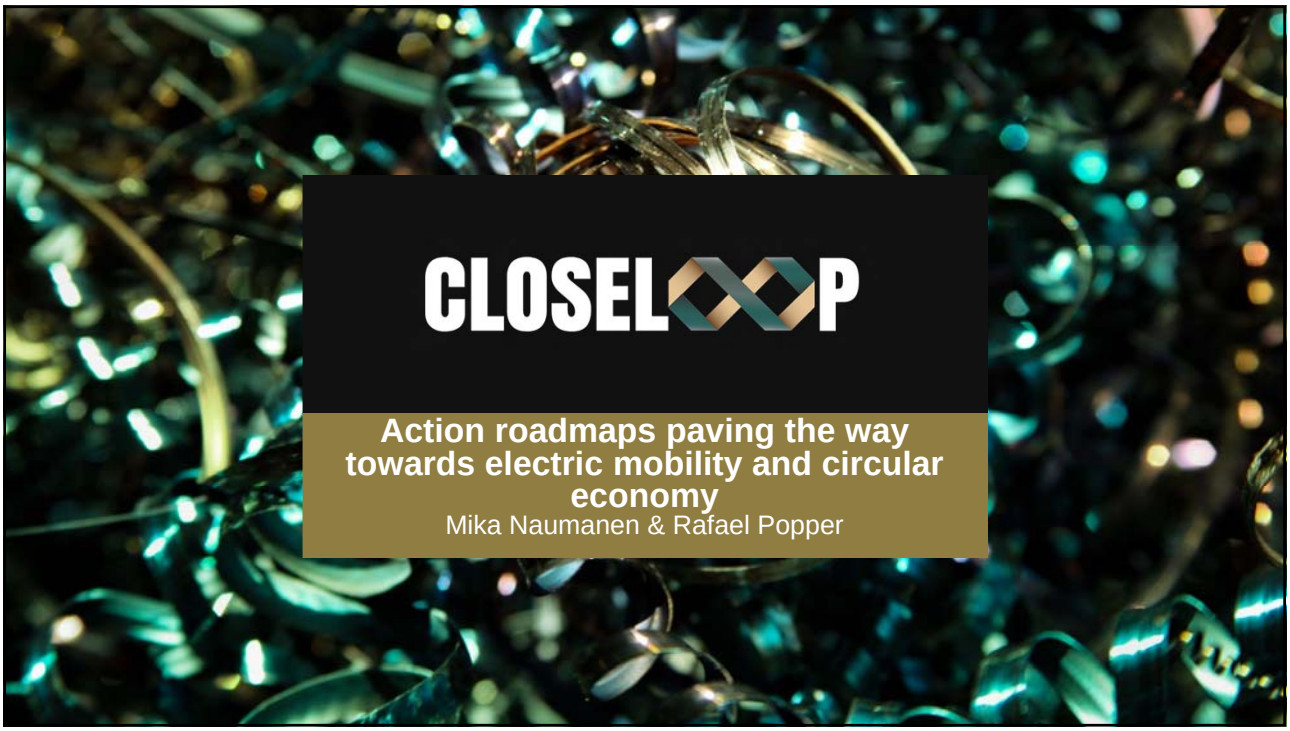
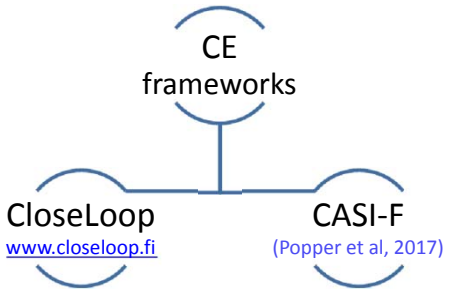


How to assess and manage sustainable innovations in the growing CE paradigm?

- We are engaged in a systematic mapping of new (innovation) design needs emerging from circular economy shapers (i.e. critical issues such as drivers, barriers, opportunities and threats) that are likely to influence the next generation of the manufacturing and data services business.



Popper, R., Velasco, G. and Popper, M. (2017) ***CASI-F**: Common Framework for the Assessment and Management of Sustainable Innovation,* CASI project report. Deliverable 6.2.

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CloseLoop rationale: from this

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To this

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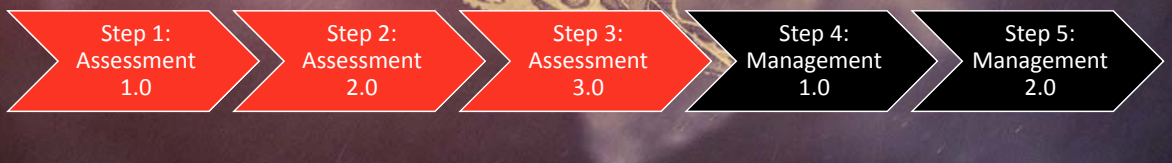
CASI-F protocols for SI assessment and management



Future-oriented assessment and management of sustainable innovations: CASI-F

*A **methodological framework** for*
***assessing** sustainable innovation and*
***managing** multi-disciplinary solutions through*
***public engagement** in the research, technology development and innovation **(RTDI) system**, by*
*ensuring the **commitment** of a broad spectrum of societal stakeholders into its **implementation**, including:*

- *government*
- *business*
- *civil society organisations and the general public*
- *research organisations and academia*

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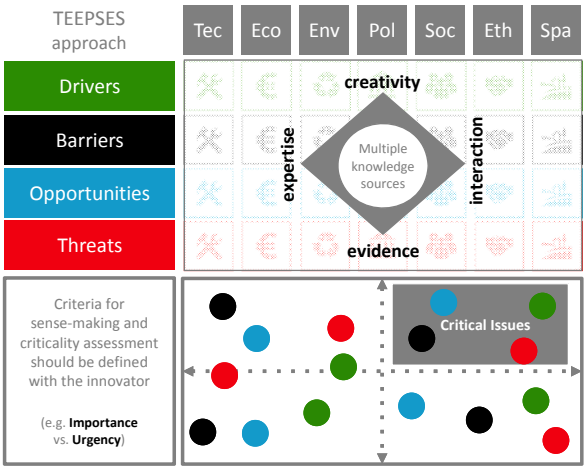
Step 3: Assessment 3.0 (critical issue analysis & assessment)

Protocol 3: Critical Issue analysis & assessment



What to do?

- Analysis of shapers and **Critical Issues (CI)**
  1. **Creativity**-based
     - Using scenarios, brainstorming, surveys, etc.
  2. **Interaction**-based
     - Using workshops, citizen panels, conferences, etc.
  3. **Evidence**-based
     - Using modelling, literature review, extrapolation, etc.
  4. **Expertise**-based
     - Using expert panel, interviews, critical technologies, etc.
- Assessment of shapers and **Critical Issues (CI)**
  1. Define two or more criteria for criticality assessment
     - E.g. **Importance**, **Uncertainty**, **Urgency**, etc.
  2. Rate TEEPSES issues against selected criteria
     - Using a **Likert-like scale** of 1 to 5 or 1 to 7
  3. Plot TEEPSES issues against a criticality chart
     - Selecting **critical issues** for management

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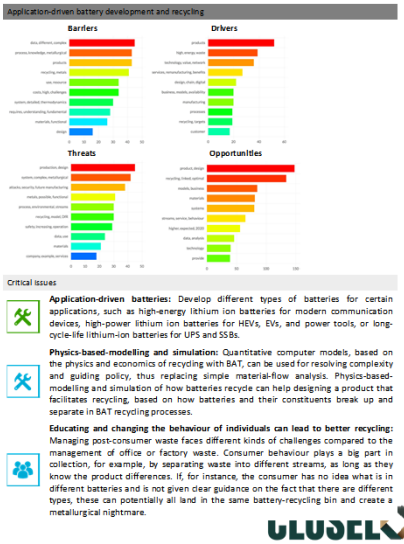
CASI-F in action (Steps 1 to 3)

- The amount (500+) and variety of critical issues (i.e. barriers, drivers, opportunities and threats) identified and prioritised in the assessment of 400+ SI called for a **multi-level and multi-actor SI management approach**.
- Such a approach should be implemented by multiple actors with different managerial roles and responsibilities.

Example of steps 1 to 3 of CASI-F applied to a product innovation

Step 1: Sustainability relevance & scanning
+
Step 2: Multi-criteria analysis & assessment

Step 3: Critical issue analysis & assessment



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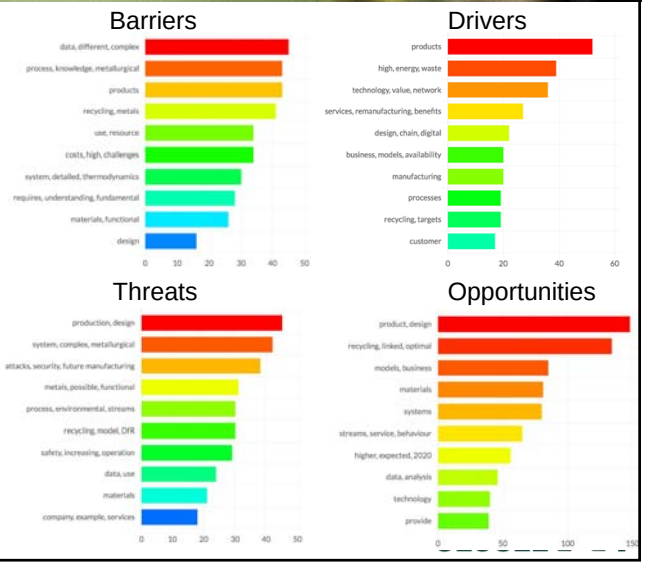
Application-driven battery development and recycling

Application-driven batteries: Develop different types of batteries for certain applications, such as high-energy lithium ion batteries for modern communication devices, high-power lithium ion batteries for HEVs, EVs, and power tools, or long-cycle-life lithium-ion batteries for UPS and SSBs.

Physics-based-modelling and simulation: Quantitative computer models, based on the physics and economics of recycling with BAT, can be used for resolving complexity and guiding policy, thus replacing simple material-flow analysis. Physics-based-modelling and simulation of how batteries recycle can help designing a product that facilitates recycling, based on how batteries and their constituents break up and separate in BAT recycling processes.

Educating and changing the behaviour of individuals can lead to better recycling: Managing post-consumer waste faces different kinds of challenges compared to the management of office or factory waste. Consumer behaviour plays a big part in collection, for example, by separating waste into different streams, as long as they know the product differences. If, for instance, the consumer has no idea what is in different batteries and is not given clear guidance on the fact that there are different types, these can potentially all land in the same battery-recycling bin and create a metallurgical nightmare.

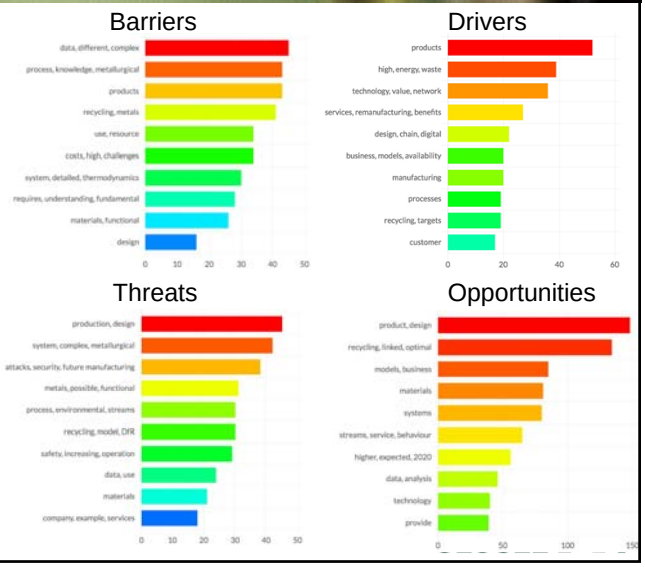


Managing physical and virtual recycling infrastructure

Data comparability: The analysis and processing of data in order to produce comparable data in each country proved to be a slow process due to the many different methods used by the participating countries for acquiring and presenting the data. A great deal of conversions between parameters such as distance, weight, cost etc.

Economic Opportunity - Big data economics: Real-time big-data approaches are evolving and can be used to calibrate metallurgical, recycling, and CE system models that create a basis to optimize the processing chain while providing the necessary detail to calculate capital expenditure (CAPEX) and operational expenditure (OPEX) in addition to the environmental footprint. The simulation basis provides the true economic potential of the CE as it rigorously maps all recoveries, losses, and costs incurred due to the recovery and losses.

Infrastructure system complexity: A robust metallurgical infrastructure and system must be in place to ensure maximum recovery of all "critical" materials from complex recyclates and dismantled functional sub-units of a product. Resource efficient recycling requires a robust high-tech interconnected metallurgical infrastructure as a crucial enabler of the EU2020 vision.



CASI-F in action (Steps 4 to 5)

- The **action roadmaps management** approach addresses the context, people, process and impact dimensions and ten related key management aspects
- The multi-level and multi-actor SI management approach should be implemented by multiple actors with different managerial roles and responsibilities.

Example of steps 4 to 5 of CASI-F applied to a product innovation

Step 4: Multi-level advice management

Step5: Action roadmaps management

SI Management Action	**Increase staff innovation management skills and capabilities**			
Action Type	**Top level management (strategic action)** - Initiate (carry out tasks never done in the past)			
Relevant actor	**Business actor (Innovator)**			
CONTEXT dimension sub-actions	**MOMENTUM** Identify and analyse database of existing innovation management programmes in international business schools and attend education fairs **Timeframe:** Medium-term	**FORESIGHT** Identify emerging management skills and capacities in the sector, through journals, conferences **Timeframe:** Short-term	**RESOURCES** Apply to local/national funds for management skills development **Timeframe:** Medium-term	**MOBILISATION** Establish new contacts with local/ regional business schools, and researchers dealing with management skills and capabilities development (become a case study in schools) and incorporate action research in the company **Timeframe:** Medium-term
PEOPLE dimension sub-actions	**APTITUDE** Create an internal repository to facilitate knowledge transfer within the company, differentiating management skills from technical education **Timeframe:** Short-term		**ATTITUDE** Foster staff creativity with participatory workshops, e.g. generate future actions through highly-transformed scenarios **Timeframe:** Long-term	
PROCESS dimension sub-actions	**CATALYSTS** Involve key stakeholders in piloting and experimenting with the firm's innovation phases **Timeframe:** Short-term		**FOSTERERS** Establish incentive procedures to reward staff professional development **Timeframe:** Medium-term	
IMPACT dimension sub-actions	**TRANSFORMATIONS** Analyse staff potential and training objectives in relation to local jobs and competences **Timeframe:** Short-term		**SUSTAINABILITY** Develop staff education plans for the employers' family so as to bring together professional and personal development **Timeframe:** Long-term	

Multi-level and multi-actor SI management approach

Multi-level & Multi-Actor (ML-MA) Approach	Government	Business	Civil society	Research & education
Top-level management: **Strategic actions**	**Strategic actions** involve the definition of high-level aims, challenges, goals, objectives and priorities that require strategic attention or orientation from top-level decision-makers in government, business, civil society, research and education organisations.			
Mid-level management: **Tactical actions**	**Tactical actions** require mid-level decision-makers to translate strategic level objectives and priorities into tactical interventions, such as investment, research or knowledge transfer programmes and calls, funding schemes or instruments as well as development and implementation mechanisms.			
Front-line management: **Operational actions**	**Operational actions** require the intervention of front-line decision-makers - policy makers, civil servants, entrepreneurs, citizens, researchers and workforce- who are directly responsible for the operationalisation of day-to-day activities linked to tactical and strategic actions.			

Some examples from football

- Number of Goals & Assists
- Number of Shots (on target)
- Number of Passes (completed)
- Number of Tackles and Interceptions
- Number of Fouls, Yellow and Red cards
- Number of Aerial duels won
- Number of Minutes played
- Number of Offsides
- Etc.

SI Management Dimensions

- **4 SI Management Dimensions** emerged from the stock-taking and sense-making analysis of 500+ critical issues or shapers of SI:
  - ✓ **Context**
  - ✓ **People**
  - ✓ **Process**
  - ✓ **Impact**

Source: Popper et al. (2017) – See also http://www.casi2020.eu/casi-f/glossary/

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SI Management Dimension 1: Context

- This dimension consists of **4 key aspects**:
  - ✓ **Momentum**, reflecting the potential space for innovation, i.e. expectations of entrepreneurs and other actors, political drive from regulators or procurement, exemplars from other technological or social enterprises, and the perception of problems that call for solutions.
  - ✓ **Create a procedure for economical efficiency evidencing by application examples. Time frame: short term**

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SI Management Dimension 1: Context

- This dimension consists of **4 key aspects**:
  - ✓ **Momentum**, reflecting the potential space for innovation
  - ✓ **Foresight**, showing the capacity to anticipate, strategise and overcome gaps in the innovation curve.
  - ✓ **Improve the reliability of prediction of recyclate input streams with variables such as: 1) Product composition, coming from consumer demand, policy change, product trends, changing technology (e. g. hybrid cars), 2) Monitoring of collected materials along the entire recycling chain, 3) Varying and changing product purchasing, affecting future waste streams, 4) Life time (usage) product distribution driven by consumer behaviour (e. g. shifting trends from mobile phones to PDA/ smart phones), 5) Disposal behaviour, 6) Collection schemes or informal collection activities. Time frame: long term**

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SI Management Dimension 1: Context

- This dimension consists of **4 key aspects**:
  - ✓ **Momentum**, reflecting the potential space for innovation
  - ✓ **Foresight**, showing the capacity to anticipate, strategise and overcome gaps in the innovation curve.
  - ✓ **Resources**, emphasising the need for healthy combinations of skills, finance, location, markets, etc.
  - ✓ **Create capabilities for real-time measurement of recyclates; this permits a detailed calculation of RE and thus the loss of materials, elements, alloys, etc. to streams of low economic value. Time frame: medium term**

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SI Management Dimension 1: Context

- This dimension consists of **4 key aspects**:
  - ✓ **Momentum**, reflecting the potential space for innovation
  - ✓ **Foresight**, showing the capacity to anticipate, strategise and overcome gaps in the innovation curve.
  - ✓ **Resources**, emphasising the need for healthy combinations of skills, finance, location, markets, etc.
  - ✓ **Mobilisation**, including champions and facilitators, civil society engagement, government engagement, research and education engagement, business engagement and proactive participation.
  - ✓ **Lower the investment risk by aiming to joint public-private investments and financing mechanisms. Time frame: medium term**

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SI Management Dimension 2: People

- Many objectives remain unfulfilled when innovations fail to connect or mobilise the right people, or do not provide the right incentives or skills for key people.
- This dimension consists of **2 key aspects** (i.e. **aptitude** and **attitude**) shaping the activities of the quadruple helix actors involved in sustainable innovation.
  - ✓ **Aptitude**, refers to the actual skillset or competences of people involved in the design, development, implementation and diffusion of a sustainable innovation;
  - ✓ **Enable consumers to make conscious product choices: Awareness needs to be created in order to generate criteria that in turn will enable consumers (end-users or non end-users) to make product choices consciously. Time frame: medium term**

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SI Management Dimension 2: People

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- This dimension consists of **2 key aspects** (i.e. **aptitude** and **attitude**) shaping the activities of the quadruple helix actors involved in sustainable innovation.
  - ✓ **Aptitude**, refers to the actual skillset or competences of people involved in the design, development, implementation and diffusion of a sustainable innovation;
  - ✓ **Attitude**, means the type of behaviour of the same people.
  - ✓ **Create ways to support cooperation between the different stakeholders in the recycling chain; to improve the system, we need a set of incentives making it worthwhile for the stakeholders to cooperate. Time frame: short term**

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SI Management Dimension 3: Process

- Innovation is widely considered a complex, participatory and multifaceted process.
- There are several critical factors that play a triggering (catalytic) or shaping (fostering) role at different stages of the innovation cycle.
- This dimension consists of **2 key aspects**:
  - ✓ **Catalysts**, contributing to initiate, develop and implement the innovation
  - ✓ **Build industrial pilot plant: pilot plant needed prior to scalable volume production. Time frame: medium term**

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- There are several critical factors that play a triggering (catalytic) or shaping (fostering) role at different stages of the innovation cycle.
- This dimension consists of **2 key aspects**:
  - ✓ **Catalysts**, contributing to initiate, develop and implement the innovation;
  - ✓ **Fosterers**, including factors that further consolidate and diffuse the innovation.
  - ✓ **Publish best practices and experience: Methods should be unified and consolidated, best practices and experiences – particularly from each of the different branches – are to be systematically documented. Time frame: short term**

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SI Management Dimension 4: Impact

- This dimension consists of **2 key aspects**:
  - ✓ **Transformation**, meaning the capacity to make positive changes in the quadruple helix of SI and knowledge production.
  - ✓ **Foster the development of new set of skills; the skills required for circular resource use include strategic thinking, engineering, marketing, logistics, process design, and change management. Time frame: medium term**

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SI Management Dimension 4: Impact

- This dimension consists of **2 key aspects**:
  - ✓ **Transformation**, meaning the capacity to make positive changes in the quadruple helix of SI and knowledge production.
  - ✓ **Sustainability**, referring to changes in the socio-technical system where the SI operates that lead to positive environmental, social, economic, government and infrastructure transformations without compromising the needs and welfare of future generations.

  - ✓ **Optimize the recycling chain by digitizing (ID tags, sensors, design tools) of all aspects of it. Time frame: long term**

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Core Team

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Mika Naumanen (MSc Tech, MSc Econ) is a senior scientist in the Innovation and Knowledge Economy group of VTT. He has run VTT's "business from technology" program and managed a portfolio of business development projects in the fields of Industrial Systems Management, Services and Built Environment, ICT and Electronics. These activities include monitoring and forecasting technology development paths as well as developing indicators and providing analysis of how these projects meet the national research and innovation policy objectives. Naumanen is a visiting scholar in Statistics Finland also.

Acknowledgements

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