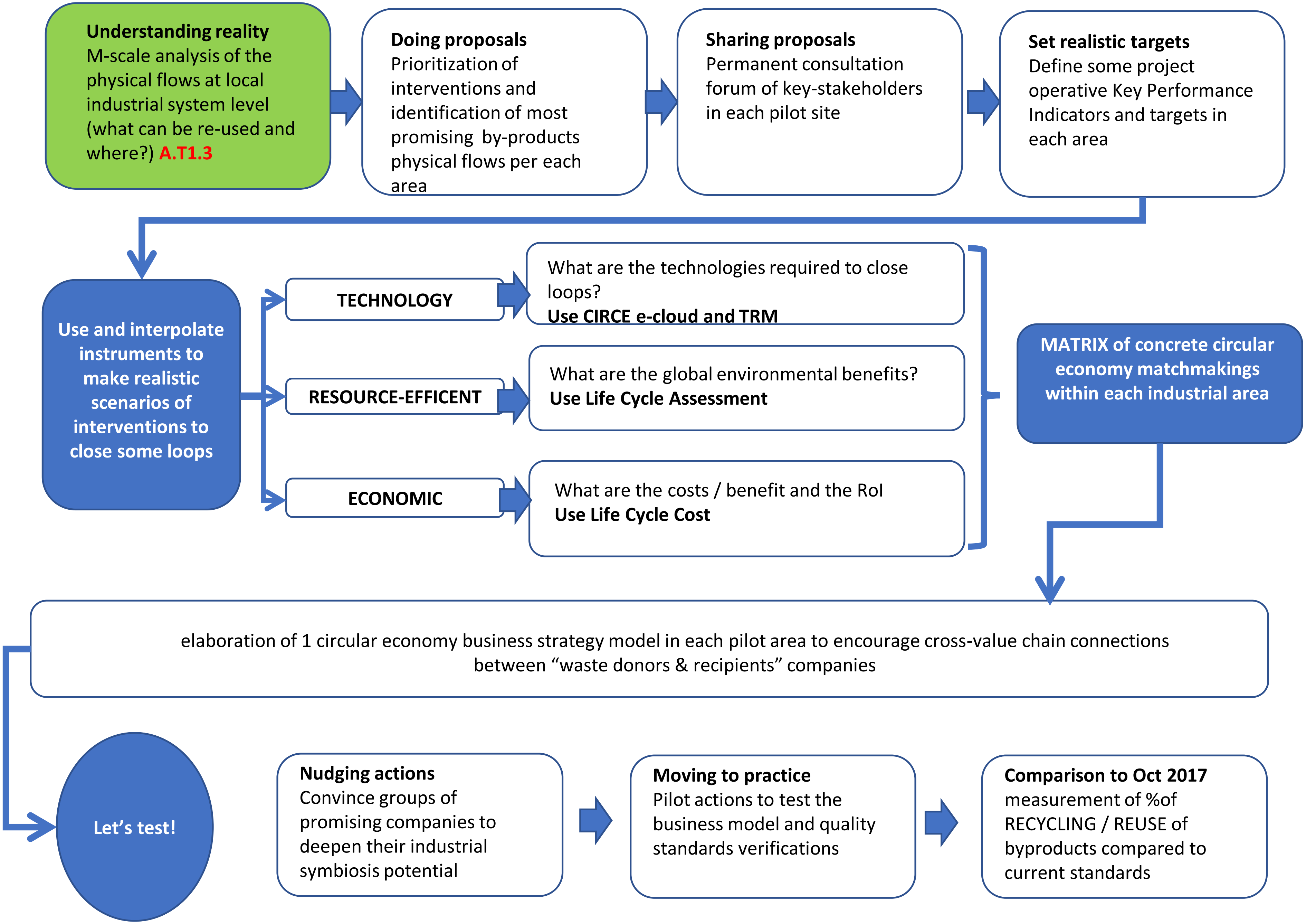
M-scale analysis of the physical flows at local industrial system level

CIRCE2020|ETRA


Understanding reality
M-scale analysis of the physical flows at local industrial system level (what can be re-used and where?) A.T1.3
Doing proposals
Prioritization of interventions and identification of most promising by-products physical flows per each area
Sharing proposals
Permanent consultation forum of key-stakeholders in each pilot site
Set realistic targets
Define some project operative Key Performance Indicators and targets in each area
Use and interpolate instruments to make realistic scenarios of interventions to close some loops
TECHNOLOGY
What are the technologies required to close loops?
Use CIRCE e-cloud and TRM
RESOURCE-EFFICENT
What are the global environmental benefits?
Use Life Cycle Assessment
ECONOMIC
What are the costs / benefit and the RoI
Use Life Cycle Cost
MATRIX of concrete circular economy matchmakings within each industrial area
elaboration of 1 circular economy business strategy model in each pilot area to encourage cross-value chain connections between “waste donors & recipients” companies
Let’s test!
Nudging actions
Convince groups of promising companies to deepen their industrial symbiosis potential
Moving to practice
Pilot actions to test the business model and quality standards verifications
Comparison to Oct 2017
measurement of %of RECYCLING / REUSE of byproducts compared to current standards

CONTEXT, GOAL AND SCOPE

Interreg CENTRAL EUROPE
European Union European Regional Development Fund
ACRONYM

Development of a M-scale analysis of the physical flows for selecting the most promising cases for Circular Economy

The **M-scale analysis** should:

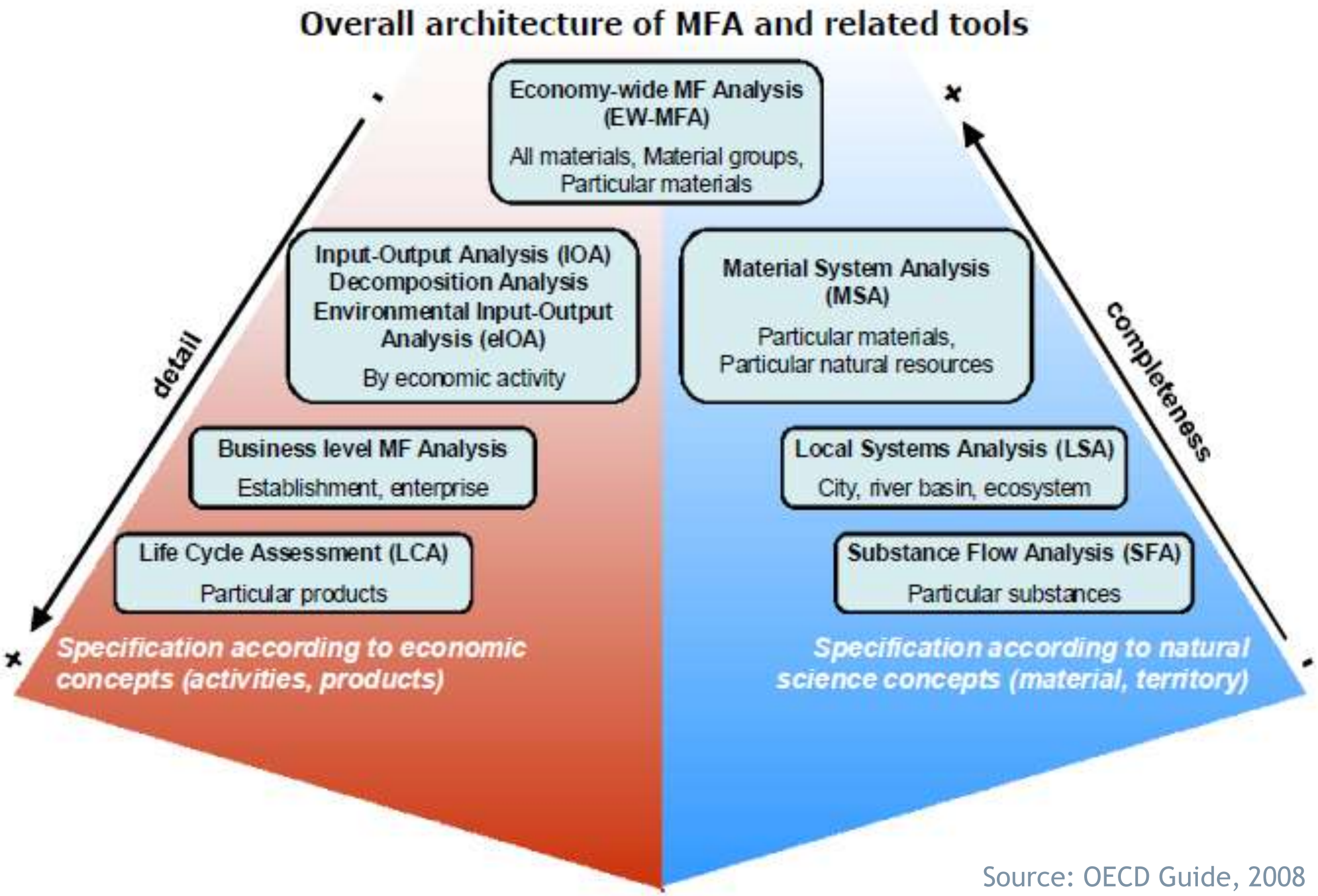
- Be inspired by the Material Flow Analysis approach, developed by WI
- Be applicable to industrial production systems at *territorial level*
- Be simple, replicable and applicable by all partners
- Be based on available data and information
- Propose proxy data and estimation methods to close data gaps
- Map and quantify raw material input, waste, by-products, residues in output and their present destination (recovery or disposal)

Interreg CENTRAL EUROPE European Union European Regional Development Fund ACRONYM

The M-scale analysis is built upon the Material Flow Analysis (MFA) approach

- MFA: "a systematic assessment of the flows and stocks of materials within a system defined in space and time." (Brunner and Rechberger, 2004)
- The term MFA designates a **family of tools**, covering a variety of *analytical approaches* and *measurement tools*.
- Scope of the tools: from economy-wide to substance or product-specific analysis, and input-output analysis, depending on data availability and on the goal of the analysis.
- Main shared principles among the different approaches and tools:
    - Mass balancing
    - Account in physical units

MFA FAMILY OF TOOLS



Source: OECD Guide, 2008

Approaches for M-scale analysis

- Top-down analysis
  - Data availability at the desired granularity
  - Detailed knowledge of the system and territory
- Bottom-up analysis
  - Built upon stakeholders engagement and knowledge
  - Inductive approach
  - Qualitative mainly, with quantitative elements

What to consider for defining the approach to be implemented in the CIRCE2020 Project?

- The information on the detailed maps of flows at territorial level is scattered among the countries
- The matching of the waste flows, at territorial (and higher) scale with the input flows (resources, including energy vectors) is hampered by the statistics and available data (the lower the scale the worse the coverage of information and data)
- Do not forget the purpose of this analysis:
  - Optimising materials use and industrial processes;
  - Creating loop-closing industrial practices
  - Resource Management: Analysis, planning and allocation, exploitation, and upgrading of waste and resources
  - Design of environmentally-beneficial goods, processes and systems

Proposed approach: inductive reasoning bottom-up approach

- Start by the knowledge of the territory by the participating organisations
- The *research question* guiding the approach is defined according to three main factors:
    - identification of the most promising cases for Circular Economy (CE);
    - analytical tools (of the MFA family) to be applied later for the assessment of the most promising cases (*Life Cycle Assessment* and *Life Cycle Costing*);
    - indicators definition and selection for the assessment and monitoring of the CE cases
- Definition of CE indicators for measuring the performance of the solutions

M-SCALE ANALYSIS IN CIRCE2020

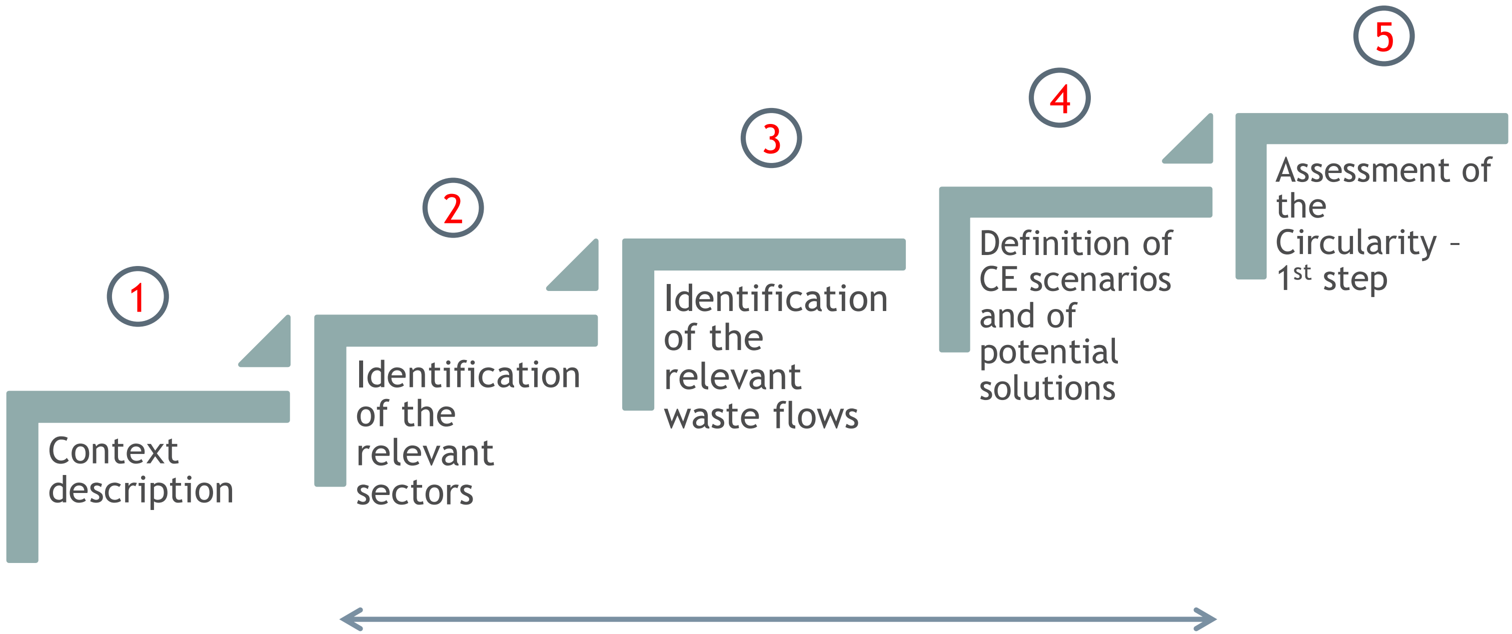
Interreg CENTRAL EUROPE ACRONYM

Proposed approach: qualitative + quantitative methods approach)

	Concepts associated with quantitative methods	*Concepts associated with qualitative methods*
Type of reasoning	Deduction Objectivity Causation	Induction Subjectivity Meaning
Type of question	Pre-specified Outcome-oriented	Open-ended Process-oriented
Type of analysis	Numerical estimation Statistical inference	Narrative description Constant comparison

Interreg CENTRAL EUROPE European Union European Regional Development Fund ACRONYM

How to implement the approach?



Stakeholder engagement

M-SCALE ANALYSIS IN CIRCE2020

Interreg CENTRAL EUROPE European Union European Regional Development Fund ACRONYM

1 Context description

What to account for in the context description:

- Geographic area
- Estimated number of enterprises, structured in ATECO sectors
- Description and list of the sectors in the CIRCE areas
- Enterprises dimensions
- Main activities
- Other relevant activities
- Specific districts/groups of homogeneous firms

In addition, coming from D.T1.3.2 and D.T1.3.3:

- Quantity of industrial waste in the CIRCE pilot areas
- Present destination of industrial waste in CIRCE pilot areas

2 3 Identification of the relevant flows

Criteria to be adopted for the identification:

- Economic turnover of the involved sectors
- Strategic relevance of the involved sectors
- Identification of the most relevant waste flows which are currently not further optimised:
  - Quantity
  - Potential of re-use, not already exploited, also from the economic point of view
  - Market demand
  - Replicability potential
- Waste flow data coming out from the analysis in the previous tasks (D.T1.2.3, D.T1.3.3)

The accomplishment of this task requires **stakeholder engagement**. How to involve them?

- Contact with regional/local industry associations
- Availability of the enterprises to be involved and collaborate

4 Definition of CE scenarios and of potential solutions

- 3 main scenarios have been identified, within which all the CE solutions could be framed:
  a. The valorisation of waste allows to substitute (partly or fully) the virgin material of the production process
  b. Changes in the production process, aimed at:
     a. Reducing the production of waste
     b. Exploiting the use of resources from waste
  c. Better management of the waste flows
- In addition, the development of a new CE solution will require the analysis of its feasibility in terms of:
  - Normative requirements and constraints (e.g.: time availability)
  - Technology feasibility
  - Logistic and organisation of the enterprises in the territory

4 Definition of CE scenarios and of potential solutions

- As far as the technology feasibility is concerned, the identification will be supported by:
  - Knowledge of the sector
  - Atlas of technology innovation, developed by ENEA, which includes also the TRL of the technology http://www.enea.it/it/ateco
  - Country-ATLAS for the circular economy
    - Example for Italy: Atlas for the circular economy (IT) http://www.economiacircolare.com/
    - Partners are invited to identify their Country-ATLAS and to disseminate them among the consortium
  - Best practices survey DT1.2.1
- In addition to technologies, also management practices will be identified as solutions for implementing CE practices.

5 Assessment of the Circularity – 1st step

- The Circularity of the solutions will be evaluated according to a three-step approach:
  - 1st step: Assessment of potential circularity of the solution, compared to the BaU* scenario, with respect to the Waste Hierarchy Indicators;
  - 2nd step: Assessment of the solution, based on application-specific indicators, to be selected among the list provided. Relative-based and not absolute assessment.
  - 3rd step: assessment of the overall environmental and economic performance of the solution through Life Cycle Assessment and Life Cycle Costing
- LCA is deemed as necessary because not all the CE solutions can bring to an increase of the environmental performance
  - Not all CE solutions are good!
  - CE solutions are not good by definition
  - Recyclability is not the only indicator to be considered for the assessment of the performance

*Business as Usual

CE PERFORMANCE INDICATORS

How to define and select the performance indicators for CE in CIRCE2020?

CE is an umbrella concept with different meanings depending on the context:

- evocative/intuitive for public opinion (easily understandable compared to “linear economy”)
- complex and questionable in scientific discussion (connecting different fields as economics, earth sciences, social science, etc)
- connected to specific “strategies” in public/private policies

Indicators to be used in CIRCE2020 Project

- Starting point for their definition is the analysis of the literature and initiatives, summarised in the previous slides
- Indicators have to be coupled with LCA and LCC evaluations
- Their selection can be done only after the identification of the potential CE opportunities as indicators need to be tailored to:
  - Sector
  - Solution provided
  - Problems tackled
  - Data collected and available

Different Levels of Circular Economy Indicators

Indicators for CE can be defined at different levels, depending on the CE strategies, objective and target audience

- **Coverage:**
  - macro (global, national, regional, territorial area)
  - meso (industrial park, inter-enterprise)
  - micro (company)
- **Level of circularity:** www.mdpi.com/2313-4321/2/1/6/pdf
  - Class A (maintain/prolong)
  - Class B (reuse/redistribute)
  - Class C (refurbish/remanufacture)
  - Class D (recycle)
- **Indicators frameworks:**
  - Homogeneous limited to mass and energy flows
  - Hybrid including economic and social parameters (eco-efficiency, governance-efficiency)

CE PERFORMANCE INDICATORS

Indicators framework: relevant, objective, credible

Approaches to criteria:

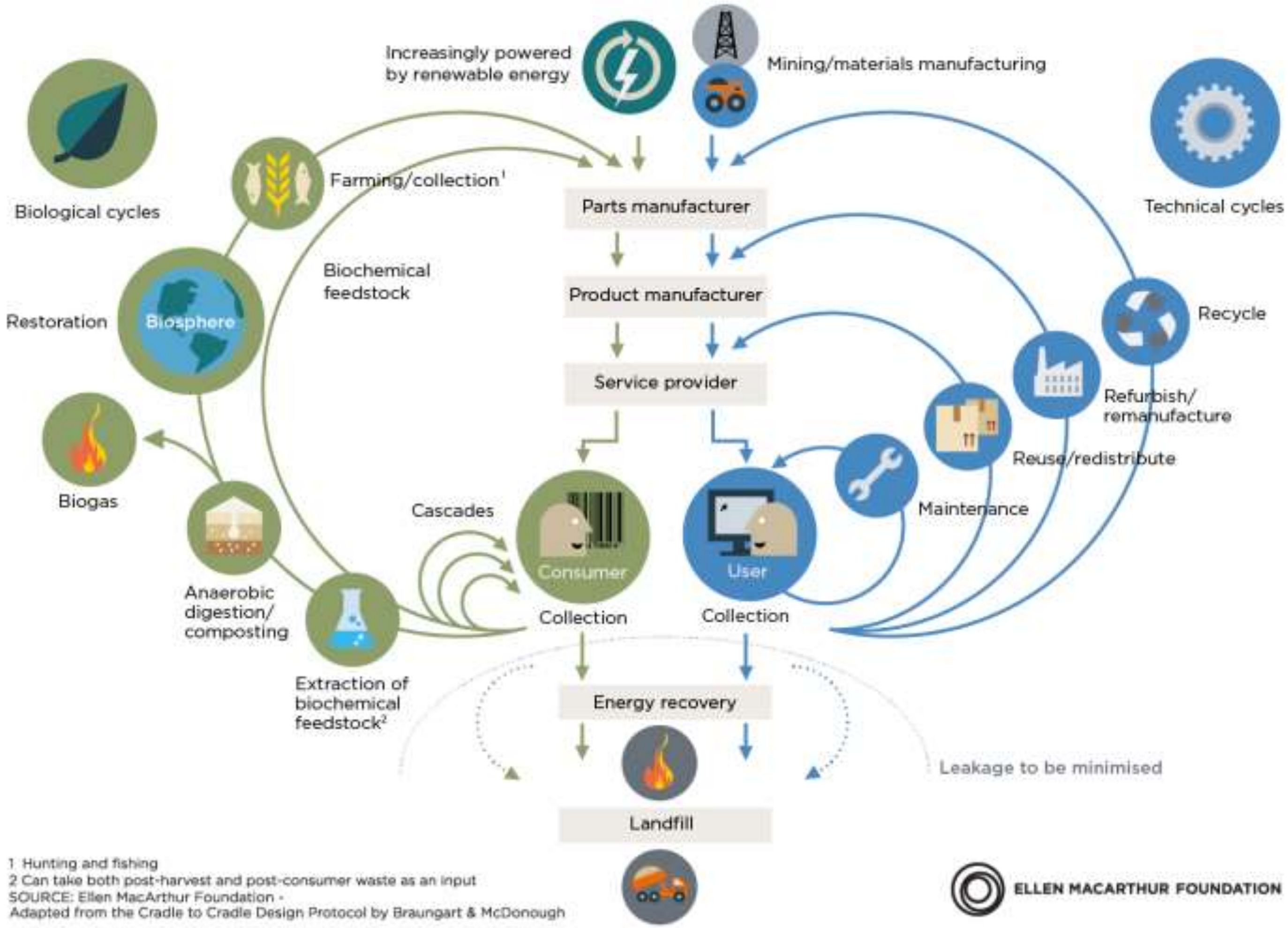
- RACRE (Relevant, Acceptable, Credible, Robust/sensitive, Easy)
- Sub criteria: reliable, verifiable, unambiguous results, realistic (available/achievable data) and replicable

Indicators for the 1st step assessment:

- Approach based on the Waste Hierarchy:
    - Prevention
    - Re-use
    - Recycling
    - Other recovery – e.g. energy recovery
    - Disposal

- Details on the excel file on how to measure them

CE PERFORMANCE INDICATORS



CE PERFORMANCE INDICATORS

Indicators for the 2nd step of the assessment: solution-specific

NAME	CATEGORY	SOURCE	Unit of measurement
Contribution of recycled materials to raw materials demand-End-of-life recycling input rates (EOL-RIR)	secondary raw material	EUROSTAT	%
Waste Hierarchy	waste	Directive 2008/98/EC	qualitative indicator
Recycling rate of all waste excluding major mineral waste	waste	EUROSTAT	%
Recycling rate of packaging waste by type of packaging	waste	EUROSTAT	%
Recycling rate of e-waste	waste	EUROSTAT	%
Recycling of biowaste (kg/(y per capita))	waste	EUROSTAT	Kg per capita (based on annual average population)
Recovery rate of construction and demolition mineral waste	waste	EUROSTAT	%
Recycling rate of industrial waste	waste	Veneto Region	%
Percentage of waste to reuse and recycle	waste	Ispra	%
Generation of industrial waste	waste	Ispra	t/y
Amount (total and single EWC) of waste to landfill	waste	Ispra	t/y
Amount (total and single EWC) of waste to incineration	waste	Ispra	t/y
Material Circularity Indicators (MCI)	circularity	Ellen MacArthur+GRANTA	
Material Supply Chain Risks	circularity	Ellen MacArthur+GRANTA	

CE PERFORMANCE INDICATORS

Interreg CENTRAL EUROPE
European Union European Regional Development Fund
ACRONYM

Indicators for the 3rd step of the assessment: life cycle approach

NAME	Indicator	Unit	Impact assessment method
LCA indicators			
Climate change	Radiative forcing as Global Warming Potential (GWP100)	kg CO2 eq	Baseline model of 100 years of the IPCC (based on IPCC 2013)
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11 eq	Steady-state ODPs 1999 as in WMO assessment
Human toxicity, cancer	Comparative Toxic Unit for humans (CTUh)	CTUh	USEtox model (Rosenbaum et al, 2008)
Human toxicity, non-cancer*	Comparative Toxic Unit for humans (CTUh)	CTUh	USEtox model (Rosenbaum et al, 2008)
Particulate matter	Impact on human health	disease incidence	UNEP recommended model (Fantke et al 2016)
Ionising radiation, human health	Human exposure efficiency relative to U^{235}	kBq $U^{235}{}_{eq}$	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al, 2000)
Photochemical ozone formation, human health	Tropospheric ozone concentration increase	kg $NMVOC_{eq}$	LOTOS-EUROS model (Van Zelm et al, 2008) as implemented in ReCiPe
Acidification	Accumulated Exceedance (AE)	mol $H+_{eq}$	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N_{eq}	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)
Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (P)	kg P_{eq}	EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	kg N_{eq}	EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe
Ecotoxicity, freshwater*	Comparative Toxic Unit for ecosystems (CTU_e)	CTUe	USEtox model, (Rosenbaum et al, 2008)
Land use	• Soil quality index • Biotic production • Erosion resistance • Mechanical filtration • Groundwater replenishment	• Dimensionless (pt) • kg biotic production • kg soil • m3 water	• Soil quality index based on LANCA (EC-JRC) • LANCA (Beck et al. 2010) • LANCA (Beck et al. 2010) • LANCA (Beck et al. 2010) • LANCA (Beck et al. 2010)
Water use	User deprivation potential (deprivation-weighted water consumption)	m^3 *world* $_{eq}$	Available WAter REmaining (AWARE) Boulay et al., 2016
Resource use, minerals and metals	Abiotic resource depletion (ADP ultimate reserves)	kg Sb_{eq}	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002.
Resource use, fossils	Abiotic resource depletion – fossil fuels (ADP-fossil)	MJ	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002
LCC indicators	to be defined		
Use of resources	Use of secondary material	kg	Indicators evaluated in Environmental Product Declarations
	Use of renewable secondary fuels	MJ	