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Taxonomy and Choice of Appropriate Set of Circularity Indicators

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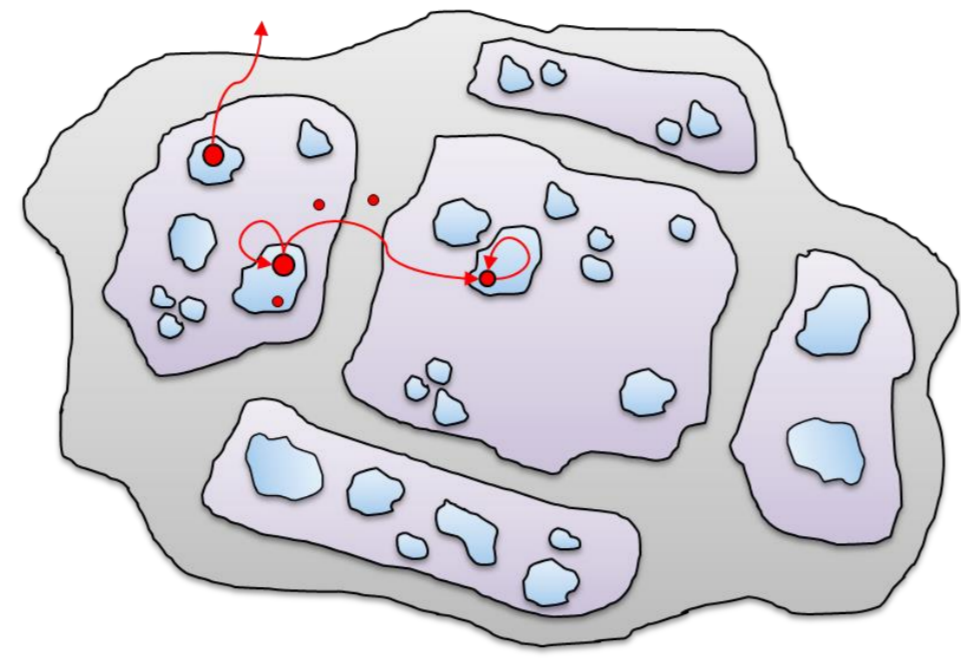
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Circularity Indicators (CI)

- The circular economy (CE) seems promising to meet the goals of sustainable development (Schroeder et al. 2018)
- Yet, **two key challenges** have still to be addressed:
 - How to support CE practitioners in this transition?
 - How to assess the circularity performance?
- Joint agreement on the need to measure the progress towards circularity in order to enhance and monitor the impacts, and benefits of this transition. (Geng et al. 2013) (EC, 2015) (Cayzer et al. 2017)



Potentially useful applications: circularity and sustainability performance assessment, improvement guidelines, decision-making, management, benchmarking, communication, etc.

- Due to an increasing number of CI with many different scopes, purposes and usages, the objective is to provide clarity on these indicators, so as to guide CE practitioners towards the right set of indicators, regarding their needs and requirements.

Level	Definition	Example
Macro	City, region, nation,	19% of the UK economy is circular in 2010
Meso	Inter-entreprise	EIPs performance
Micro	Company, Products, Materials	Material Circularity Indicator

Selection Tool

1. Presentation

Goal: To support the users in identifying and selecting the most appropriate circularity indicators in line with their objectives.
Audience: Industrial practitioners (e.g. designers, engineers, managers) decision-makers and policy-makers working in CE projects.
Software: Microsoft Excel worksheet based tool with macro enabled.
Database: A pool of more than 50 sets of circularity indicators.

2. Input Data

In the *input interface* of the Excel file, one can specify the desired features, by answering 8 multiple-choice questions, e.g. if one is interested in measuring the inherent circularity (i.e. recirculation of resources) or the consequences (i.e. impacts) of such circularity?

3. Run the Search

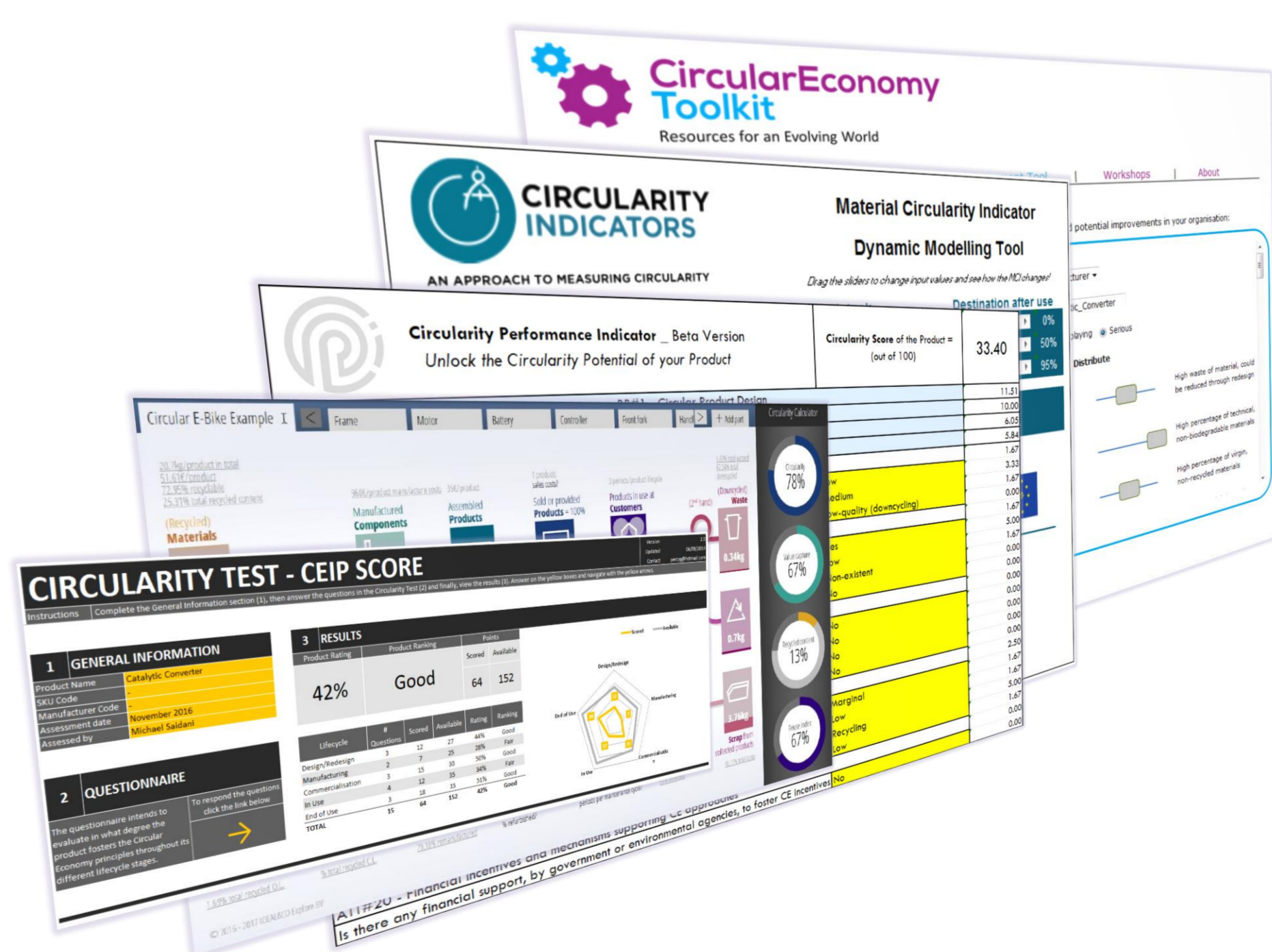
Once the *query* is completed, a click on the round logo at the top starts the search.

4. Outputs

The tool directs automatically to the *results table* of recommended indicators. It includes a short description of each selected indicator, its working principle, the data required to be computed, and a summary of its potentially useful usages.

5. Explore, Test, & Implement

A direct *internet access link* to each of the recommended indicators and their assessment framework is also indicated, to get more details on the indicator, to experiment their associated assessment framework (e.g. formulas to compute, web-based tool, dynamic Excel spreadsheet, etc.) and, if relevant, to start implementing such indicator(s) in diverse circular economy project(s).



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Proposed Taxonomy

- Research approach** = Extensive literature review on CE-related indicators.
- Identification, analysis and classification of **over 50 sets of circularity indicators** developed and used by academics, businesses, consulting companies, environmental organisations and governmental agencies.
- In line and in complementarity with existing taxonomies of eco-design tools** (Rousseaux et al. 2017) (Bovea and Pérez-Belis, 2012) **and of circular economy business models** (Urbinati et al. 2017)
- Clustering method: Proposition of a **need-based taxonomy**, driven by the usages of such indicators.
- Combinatory aspects: The approximately 200 possible pathways thought criteria combination - among the 50 sets of indicators inventoried - ensure a **rapid convergence towards the most suitable circularity indicator(s)**.

Categories (criteria)	Levels (micro, meso, macro)	Loops (maintain, reuse/reman, recycle)	Perspective (actual, potential)	Performance (intrinsic, impacts)	Units (quantitative, qualitative)
	Dimension (single, multiple)	Usages (e.g. improvement, benchmarking, communication)	Sources (academics, companies, agencies)	Transversality (generic, sector-specific)	Format (e.g. web-based tool, Excel, formulas)

Circularity Indicators - The Advisor
 Target the Right Indicators for Your Organization

Inputs - Filtering
 Selection Criteria

- Instruction -

1/ Fill in the yellow cells that can be scrolled, as a filter to identify the most suitable circularity tool(s)/indicator(s) to your needs ↓↓↓
 2/ Click on the logo above to launch the search and have access to your personalised inventory of circularity tools/indicators. ↑↑↑
 N.B. You can leave one or several criteria blank to have access to a wider variety of proposed solutions.
 For instance, if all criteria fields are left empty, every tool available among the inventory will be displayed.

<p>*Scale of Measurement* Are you focused on the circularity of products, components, materials (micro), of a company, organization, industrial symbiosis, eco-park, value chain (meso), of a region or nation (macro) ?</p>	Micro
<p>*Circularity Perspective (Retro- or Pro-)* Are you interested in knowing actual and effective circularity performances (retrospective) or potential performances of circular practices e.g. during product development (prospective) ?</p>	Potential
<p>*Circularity Performance* Are you willing to evaluate the intrinsic performance of your circularity loops (recirculation of resources) or the impacts/consequences of circular practices on the sustainability performance ?</p>	Intrinsic (Recirculation of Resources)
<p>*Circularity Loop* Are you considering a particular loop/class of the circular economy (i.e. Class A = Maintain & Prolong ; Class B = Reman. & Reuse ; Class C = Recycle) ?</p>	
<p>*Dimensionality* Are you looking for more particularly for a tool with a single and unique indicator or for a framework including a set of multiple indicators ?</p>	
<p>*Usages & Purposes* (Filter Not Available - Under Construction)</p>	
<p>*Transversality* Are you looking for generic tool(s)/indicator(s) that could be applied for a wide variety of products/organizations or for more specific ones designed for a particular industrial field ?</p>	
<p>*Type & Format* What kind of tool(s)/indicator(s) would you prefer to use ?</p>	Formulas to compute Computational tool Dynamic Excel Spreadsheet Web-based Tool Assessment framework

Use Cases - Experimentation

Circularity Indicators - The Tool Seeker
 Target the Right Indicators for Your Organization

Outputs - Extraction
 Information Displayed

The following results table has been computed successfully. Please find below the features of circularity tool(s)/indicator(s) that are matching with your defined criteria. We hope you will find them useful.
 For further critical analysis, and to know if experimentation of some tools/indicators are available in the literature, please check out the Taxonomy tab below.

The query tool is flexible and the databank is not frozen and can be easily updated. Therefore, if you are aware of CE-related tools/indicators that are not inventoried here and/or if you want to contribute to the tool's development, experimentation and/or implementation, please let us know by sending an email to: michael.saidani@centralesupelec.fr

Circularity Measurement Instruments/Tools (Indicators, Metrics, Indexes, Framework)	Definition - Description Working Principles (Inputs/Outputs)	Systemic level	Kind of Circularity	Dimensionality and Units	Data Required (Systemic & Life Cycle Thinking)	Possible Usages of the tool (non-exhaustive)	Authors & References	Type of Tools (Excel, App, Web-based, Formulas, etc.)	Access Link
Reuse Potential Indicator (RPI)	The RPI indicates how much a material is "resource-efficient" in a product.	Material-Centric	Intrinsic (Recirculation)	Single Indicator	Bill of Materials, plus information on the material's lifecycle.	(Park and Chen)	Computational tool	https://www.reusepotential.com/	
Circular Economy Toolkit (CET)	The CET is a "five-minute assessment tool" which assesses the circularity of a product.	Product-Centric	Intrinsic (Recirculation)	Multiple Indicators	Extensive qualitative knowledge of the product's lifecycle.	(Evans and Book)	Web-based Tool	https://circular.eco-design.com/	
Circularity Potential Indicator (CPI)	Through a guided questionnaire of twenty attributes, the CPI assesses the circularity potential of a product.	Product-Centric	Intrinsic (Recirculation)	Single Indicator	Data required are both technical (BOM) and non-technical (e.g. market data).	(Saidani et al. 2017)	Dynamic Excel Spreadsheet	https://www.circularitypotential.com/	
Resource Duration Indicator (RDI)	A new performance metric, the longevity indicator, measures the duration of a product's lifecycle.	Components, Product-Centric	Intrinsic (Recirculation)	Single Indicator	Initial lifetime, extended, refurbished life.	(Franklin, Johns)	Formulas to compute	https://www.resource-duration.com/	

- Focus on the micro level of CE (i.e. company, products, components and materials):
- To explore how appropriate CI can help (re-)designing better circular products.
- To experience the tool on CI use cases published in literature to test its robustness (e.g. on used starter engines, prototype tidal energy device, and catalytic converter).
- Perspectives:** to link CI heuristics with tangible impacts; to keep the databank up-to-date.



→ Tutorial video <https://youtu.be/nRNbWyHRzic>

→ Industrial application <https://youtu.be/kd51SsX0Be4>