

CIRCULARITY INDICATORS

An Approach to Measuring Circularity

PROJECT OVERVIEW



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GRANTA
MATERIAL INTELLIGENCE



Executive Summary

A circular economy is a global economic model that aims to decouple economic growth and development from the consumption of finite resources. Increasingly, companies see tremendous opportunity in this model, as it not only allows them to capture additional value from their products and materials, but also to mitigate risks from material price volatility and material supply.

Until now, there has been no established way of measuring how effective a company is in making the transition from 'linear' to 'circular' models, nor have there been any supporting tools. The Circularity Indicators Project aims to address this gap and has developed indicators that measure how well a product or company performs in the context of a circular economy, thereby allowing companies to estimate how advanced they are on their journey from linear to circular.

The developed indexes consist of a main indicator, the Material Circularity Indicator, measuring how restorative the material flows of a product or company are, and complementary indicators that allow additional impacts and risks to be taken into account.

The indicators can be used as a decision-making tool for designers, but might also be used for several other purposes including internal reporting, procurement decisions, and the rating or evaluation of companies.

The Circularity Indicators Project has also contributed to the development of a web-based assessment system for product designs that provides businesses with the tools required to track their progress in delivering circular economy based business models.

ABOUT THE AUTHORS: ELLEN MACARTHUR FOUNDATION AND GRANTA DESIGN

The Ellen MacArthur Foundation launched in 2010 to accelerate the transition towards the circular economy.



The Foundation believes that a circular economy provides a coherent framework for systems level redesign and, as such, offers us an opportunity to harness innovation and creativity to enable a positive, regenerative economy.

The Foundation's team is grateful for the support by expert advisor Chris Tuppen and his contributions throughout the project.

Granta Design is a materials engineering software company, spun-out in 1994 from the work of Mike Ashby and David Cebon at the University of Cambridge.



Granta works with leading engineering enterprises worldwide. Its Education Division supports teaching at over a thousand universities. Granta takes a collaborative approach, particularly through its Consortia. The Materials Data Management Consortium (MDMC) and Environment Materials Information Technology (EMIT) Consortium guide development and effective application of Granta technology. These projects, with members such as Airbus Helicopters, Boeing, Emerson Electric, NASA, and Rolls-Royce, have supported development of the GRANTA MI™ materials information management system, and of tools such as MI:Product Intelligence for minimising product risk and design-stage environmental assessment. The LIFE collaboration extends the scope to product circularity.



LIFE is the EU's financial instrument supporting environmental and nature conservation projects throughout the EU, as well as in some candidate, acceding and neighbouring countries. Since 1992, LIFE has co-financed some 3954 projects, contributing approximately EUR 3.1 billion to the protection of the environment.

What is a circular economy?

The current economy can be largely described as linear: virgin materials are taken from nature and used to make products, which are then consumed and eventually disposed of.

This model gives rise to chronically high levels of waste and creates dependence between economic development and inputs of new virgin materials. In a world of finite resources, this model cannot work in the long run, and there are indications that it is reaching its limits.

In contrast, a circular economy is a global economic model that aims to decouple economic growth and development from the consumption of finite resources. It is restorative by design, and aims to keep products, components and materials at their highest utility and value, at all times. Unlike a linear economy, it is about optimising systems rather than components. This includes careful management of materials flowing in both biological and technical cycles. In technical cycles, materials are maintained, reused, refurbished and (as a last resort) recycled. In biological cycles, non-toxic materials are cascaded and eventually returned to the soil, thus restoring natural capital.

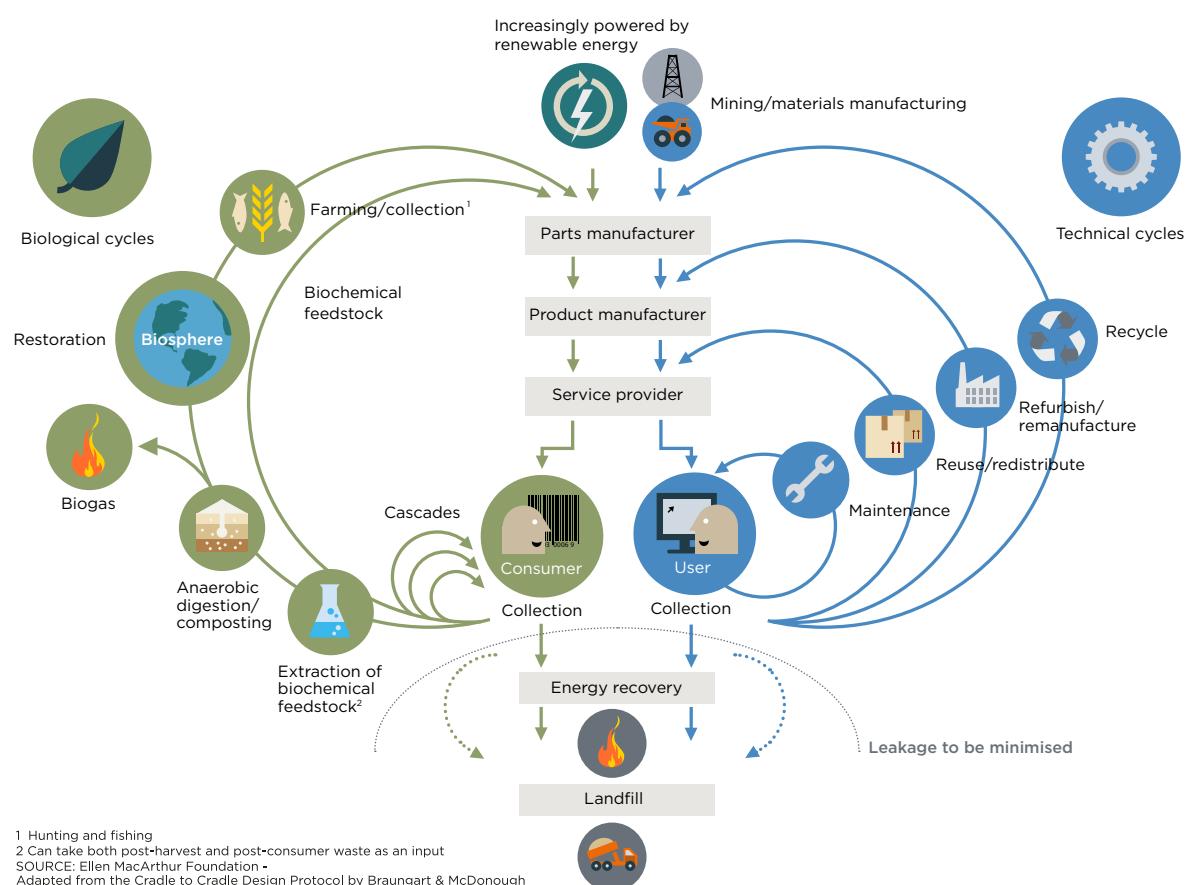
These different strategies are illustrated on the circular economy systems diagram below. The tighter the cycle the more economic value is retained.

The successful implementation of circular models depends on the combined leveraging of key building blocks including product design, new business models, reverse logistics and systems conditions.

Economic opportunities from implementing a circular economy are tremendous. Just in terms of materials costs, the model has been estimated to enable savings of USD 630 billion for medium-lived complex goods in the EU¹ and USD 706 billion for fast-moving consumer goods globally.² Additionally, more circular models allow businesses to mitigate risks from material price volatility and material supply.

¹ The Ellen MacArthur Foundation, Towards the Circular Economy, Volume 1, 2012

² The Ellen MacArthur Foundation, Towards the Circular Economy, Volume 2, 2013



¹ Hunting and fishing

² Can take both post-harvest and post-consumer waste as an input

SOURCE: Ellen MacArthur Foundation - Adapted from the Cradle to Cradle Design Protocol by Braungart & McDonough

Rationale and Background

MATERIAL PRICE CHANGES

Many companies have begun to notice increases in their exposure to risks, most notably higher resource prices and supply disruptions.

More and more businesses feel squeezed between rising and less predictable prices in resource markets on the one hand and high competition and stagnating demand for certain sectors on the other. The turn of the millennium marked the point when the downwards trend in real prices of natural resources stopped, while price volatility increased for a number of commodities.

These trends will be exacerbated by expected increases in demand: Globally, the consuming middle classes are expected to swell from 1.8 to 4.9 billion people by 2030. Demand for all commodities is expected to rocket by 30% to 80% by 2030.

"The auto industry consumes about 15% to 20% of the global steel production, in 2004 the price of steel rose 60% in one year and did not significantly decline until 2008. Without circular economics sudden exposure to price fluctuations is a permanent condition of doing businesses."

Carlos Tavares, COO, Renault

DECOUPLING GROWTH FROM RESOURCE CONSTRAINTS

In contrast to the linear model, a pattern of resource deployment that is circular by design allows further growth without the need for more resources.

It creates much more value from each unit of resource by recovering and regenerating

products and materials after their use. Additionally, designing and using durable goods, such as cars and vans, washing machines and mobile telephones, in accordance with circular principles, offers tremendous materials saving opportunities.

MCKINSEY COMMODITY PRICE INDEX (YEARS 1999 - 2001 = 100)



"Two years ago, we decided to embed circular economy thinking in our strategic vision and mission, both as a competitive necessity and with the conviction that companies solving the problem of resource constraints will have an advantage."

Frans van Houten, CEO, Philips

Measuring Circularity

METRICS AND TOOLS FOR A CIRCULAR ECONOMY

In order to inform their decision making, companies use a number of metrics and tools in all aspects of their business, from product design to reporting.

Currently, though, there is no recognised way of estimating how effective a product

or company is in making the transition from a linear to a circular mode of operation, nor are there any tools supporting such measurements. Such tools will provide further proof of the economy-wide and business-specific rationale for accelerating the transition to a circular economy.

THE CIRCULARITY INDICATORS PROJECT

The objective of the Circularity Indicators Project is to close this gap thanks to a methodology providing indicators to estimate the circularity of products and businesses.

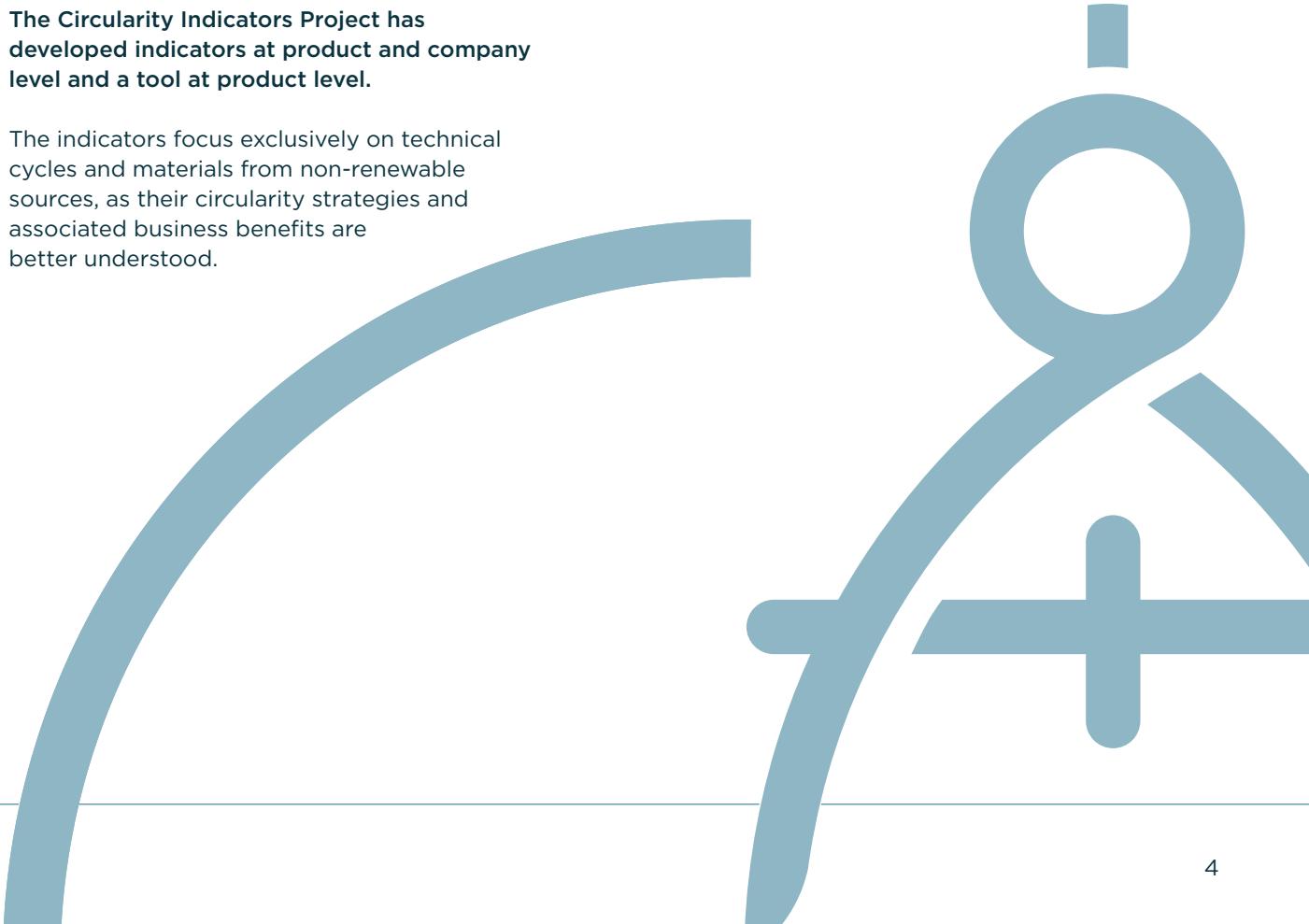
The developed Circularity Indicators are particularly intended for use in product design, but could also be used in internal reporting or for procurement and investment decisions. Furthermore, variants or extensions of the indicators could be used in education, research, rating or policy making.

The development of the methodology included the participation of leading European businesses, who provided product data to test, and other stakeholders including universities and investors who worked with the project team to develop, test and refine the measurement system to ensure its robustness and relevance.

SCOPE OF THE INDICATORS

The Circularity Indicators Project has developed indicators at product and company level and a tool at product level.

The indicators focus exclusively on technical cycles and materials from non-renewable sources, as their circularity strategies and associated business benefits are better understood.



The Circularity Indicators

The project has focused on quantifying the restoration of material flows and the development of a **Material Circularity Indicator** (MCI). Other considerations (e.g. toxicity, scarcity and energy) are included as complementary indicators.

The indicators have been developed on a product and company level. The Circularity Indicators methodology also contains a section giving guidance to help estimate the profitability of circular economy business initiatives.

THE MATERIAL CIRCULARITY INDICATOR FOR PRODUCTS

The diagram below shows the material flows taken into account to arrive at the **Material Circularity Indicator** of a product. The MCI gives a **value between 0 and 1 where higher values indicate a higher circularity**.

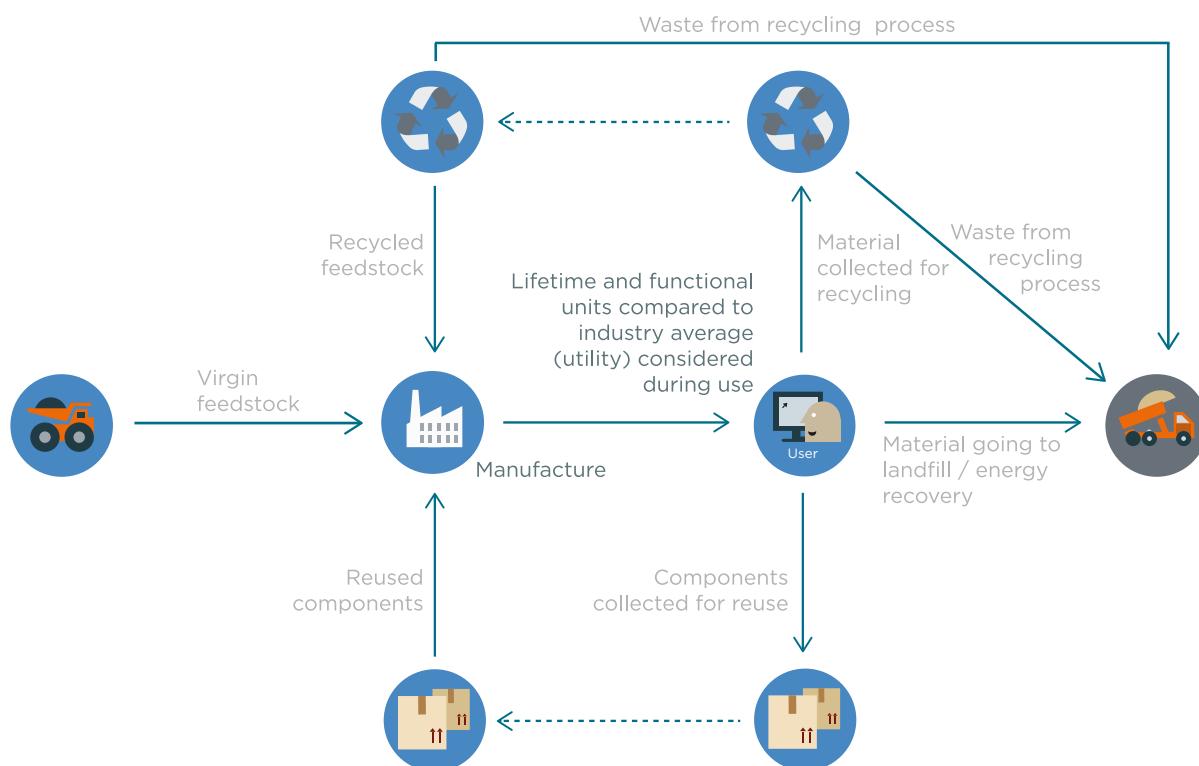
More specifically, the following inputs are used to calculate the MCI:

- **Input in the production process:** How much input is coming from virgin and recycled materials and reused components?
- **Utility during use phase:** How long and intensely is the product used compared to an industry average product of similar

type? This takes into account increased durability of products, but also repair/maintenance and shared consumption business models.

- **Destination after use:** How much material goes into landfill (or energy recovery), how much is collected for recycling, which components are collected for reuse?
- **Efficiency of recycling:** How efficient are the recycling processes used to produce recycled input and to recycle material after use?

A detailed **bill of materials** for the product is needed to compute the MCI, listing the above data for all its components and materials.



COMPLEMENTARY RISK AND IMPACT INDICATORS FOR PRODUCTS

The complementary indicators are optional indicators that can be used alongside the MCI to offer additional business management insight into the product:

- **Complementary risk indicators** may provide further insights into potential risks in relation to business priorities.
- **Complementary impact indicators** may provide additional information to evaluate

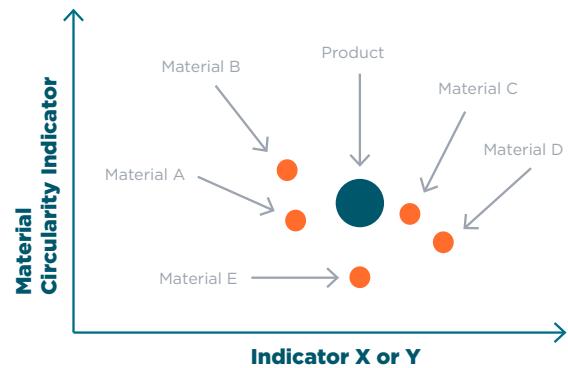
how changing the level of material circularity affects other impacts of interest to businesses and their stakeholders.

Examples for complementary risk indicators include **material price variation, material supply chain risks, material scarcity and toxicity**. Complementary impact indicators can include, for example, **energy usage and CO₂ emissions**.

The complementary indicators help to answer:

- **Which materials, parts or products should I focus on?**
- **My business priorities are X, Y & Z, where is my risk?**

Example:	Indicator X	Indicator Y	etc...
Product risk:	XX	YY	
Materials breakdown:			
Material A	XX	YY	
Material B	XX	YY	
Material C	XX	YY	
etc...			



COMPANY LEVEL INDICATORS

The company-level Material Circularities Indicator is based on the hypothesis that the material circularity of a company can **be built up from the material circularity of the company's products**. That is, to determine the MCI for a company one needs to know the MCI for all product types of that company, which are then aggregated by a suitable weighting.

For many businesses, it would not be practical to undertake an MCI assessment for every single product it places on the market. The company methodology therefore takes a **reference product approach** so that the MCI only needs to be computed for a list of reference products, each of which represent a range of similar products.

Furthermore, a **de minimis rule** allows the disregarding of departments or products in the computation of a company-level MCI when their contribution is below a certain threshold. The MCI of a company is then obtained by taking a **weighted average** of reference product MCIs using either **mass or revenue as a normalising factor**.

Complementary indicators on the company level can either be built up in a similar way from product-level complementary indicators, or those already established at the company level, for example, using indicators from the Global Reporting Initiative (GRI) guidelines.

Application Examples

Due to the commercial sensitivity of the data it has not been possible to disclose results for actual products. However, the following cases have been developed to illustrate how the Circularity Indicators can be used, and are inspired by actual examples and real world cases of companies adopting circular economy principles.

WIDGET STORE – COMPARING THE CIRCULARITY OF EXISTING PRODUCTS

Sue, the head designer of *Widget Store*, wants to compare the circularity of *Widget Store*'s products.

The company produces a predominantly ABS plastic **standard widget** and a predominantly aluminium **premium widget**.

Standard Widget

Material	Mass (kg)	Recycled feedstock	Recycling efficiency
Aluminium	2	50%	90%
ABS	8	0%	40%

Premium Widget

Material	Mass (kg)	Recycled feedstock	Recycling efficiency
Aluminium	8	50%	90%
ABS	2	0%	40%

The plastic is from virgin sources and the aluminium supplier uses half recycled, half virgin input. Collection data for *Widget Store*'s main markets show that three quarters of the aluminium and one quarter of the ABS are usually recycled. However, the ABS is mixed in with other plastics during the collection process resulting in a much lower recycling efficiency compared to the aluminium.

Sue has access to the latest customer survey that shows *Widget Store*'s standard widgets are usually used for 8 years and premium widgets for 12 years, while the industry average is 10 years.

Using a tool based on the Circularity Indicators methodology, Sue computes the **Material Circularity Indicator** of the **standard widget** to be **0.06** and that of the **premium widget** to be **0.61**.

WIDGET STORE – DESIGNING A NEW CIRCULAR WIDGET

After learning more about the circular economy, and circular products and business models, Sue convinces Maria, the CEO of *Widget Store*, to trial a new widget better leveraging circular economy opportunities. Sue uses her Circularity Indicators tool to test the circularity of possible designs. The product she settles on in the end is still made of aluminium and ABS but only uses material feedstock from recycled sources. Working with their suppliers and customers, *Widget Store* also introduces a closed-loop return system, meaning that *Widget Store* collects all old widgets after their use. Sue assumes that 83% of the aluminium components can be reused while the rest of the product is going into

two mono-material recycling streams which also allows for an increase in the recycling efficiency. The lifetime of the new widget is expected to be similar to the existing premium products.

The **Material Circularity Indicator** of the newly designed **circular widget** is **0.98**.

Circular Widget

Material	Mass (kg)	Recycled feedstock	Recycling efficiency
Aluminium	6	17%	90%
ABS	1	100%	80%

WIDGET STORE - PROFITABILITY AND BUSINESS MODELS

Using the guidance on economic benefits in the Circularity Indicators methodology, Sue works together with Marc, an analyst from *Widget Store's* Finance team, to produce a business case for the new circular widget. They identify significant manufacturing cost savings through component reuse and, furthermore, increased customer loyalty due

to the take-back process. Additionally, *Widget Store* offers a rental model whereby the customer can pay a service charge rather than buying the widget outright, attracting some new customers. Overall, the business case for the new circular product is very attractive, not only demonstrating higher margins but also increasing customer loyalty.

ACME COMPANY - COMPLEMENTARY INDICATORS

The *ACME Company* produces portable electronic tablets. William, *ACME's* Chief Tablet Designer, is tasked to create a more circular design, while also considering and not overlooking other *ACME* key performance indicators: REACH compliance, carbon footprint, price variation and supply chain risks.

In the tablet redesign, aluminium is used instead of plastic for the casing - avoiding the use of a flame retardant regulated by REACH

and allowing easier reuse - and a take-back scheme is planned for reuse of the casing and the front glass cover of the LCD display. The **Material Circularity Indicator** of the **tablet** increases from **0.10** to **0.46** thanks to the redesign.

In terms of risks and impacts, in addition to the absence of the REACH regulated substance, the new design delivers a lower proportion of high risk substances as well as a marginal decrease in its carbon footprint.

WIDGET STORE - COMPANY LEVEL CIRCULARITY

The *Widget Store* board was so impressed by the commercial success of the new circular widget that it made circularity an important part of the company's business strategy and wants to compute the company's Material Circularity Indicator.

Widget Store's Widgets Department produces several kinds of standard, premium and circular widgets, and the specific products considered earlier serve as reference products for these ranges.

Using the revenue numbers for the different widgets and computing a weighted average yields **0.60** as the **Material Circularity Indicator** of the Widget Department. In addition to the Widget Department, *Widget Store* has two further departments: a Flange Department and an Accessories Department.

As the Accessories Department only accounts for 0.6% of total revenue, it is not included due to the *de minimis* rule. The Flange Department only contains one product range and the reference product for this product range has an MCI of **0.57**. Using the total revenue numbers of the two departments and computing a weighted average, the **Material Circularity Indicator for Widget Store** results in **0.60**.

Widget Store also incorporates this analysis in their annual report to shareholders, highlighting the commercial success of their circular widget range. A number of industry analysts, struck by these insights, asked other companies in the sector to disclose similar information. This led to circularity becoming an important competitive issue in the industry.

Circularity Indicators Webtool

The commercially-available Circularity Indicators webtool has been developed by Granta Design and integrated with the MI:Product Intelligence™ package, which enables users to analyse and evaluate a range of environmental, regulatory and supply chain risks for their designs and products.

With MI:Product Intelligence, users can either import, build and edit bills of materials for products or designs through an easy-to-use web application, MI:BoM Analyzer™, or they can work within a CAD system. In either case, users can run reports that analyse bills of materials in order to assess product risk and guide design decisions. A new Circularity Report, based on the Circularity Indicators methodology, is available in the BoM Analyzer web application. This report analyses environmental, regulatory and supply chain risks alongside the Material Circularity Indicator.

ABOUT MI:BOM ANALYZER: AN OVERVIEW

GRANTA MI:BoM Analyzer enables you to import and edit bills of materials ('BoMs') for products or product designs, or build new BoMs from scratch, and then run reports that assess product risk and support better informed design decisions.

MI:BoM Analyzer is part of the GRANTA MI™ materials information management system. It is an easy-to-use web application that

connects to a GRANTA MI database on your corporate Intranet or elsewhere on the cloud, enabling you to access a wealth of material, process, and environmental data. You can then apply that data to your company's products or product designs, and quickly generate information on factors such as product mass, environmental impact or regulatory and supply risk.

CIRCULARITY INDICATORS IN MI:BOM ANALYZER

The Circularity Report can be used to analyse the extent to which a product's material usage can be regarded as circular, as measured by its Material Circularity Indicator. The report includes a range of complementary risk and impact indicators that can be used to assess other risks and impacts relating to material use, and to prioritise product improvements:

- complementary risk indicators: material price variation, REACH obligations, conflict material reporting risk and RoHS compliance
- complementary impact indicators: energy usage, CO₂ footprint and water usage

The report shows values for these indicators at three levels of analysis:

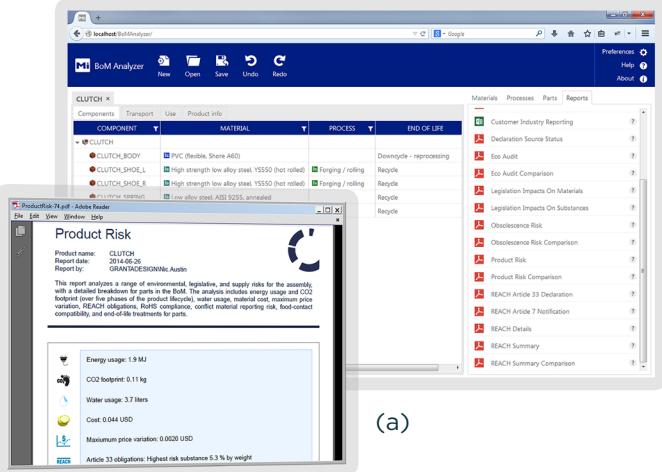
- an overall summary for the product as a whole

- an initial breakdown for parts and sub-assemblies that are immediately below the product level in the BoM hierarchy
- a full breakdown for material components used in the product, at the lowest level of the BoM hierarchy. This level of analysis includes additional risk indicators that reflect critical material supply risks (abundance risk, environmental country risk, sourcing and geopolitical risk, and monopoly of supply), and obsolescence risk for materials containing restricted substances.

After viewing the Circularity Report in MI:BoM Analyzer, you can view a range of specialised reports that provide more detail for the complementary indicators. These are listed in the table opposite.

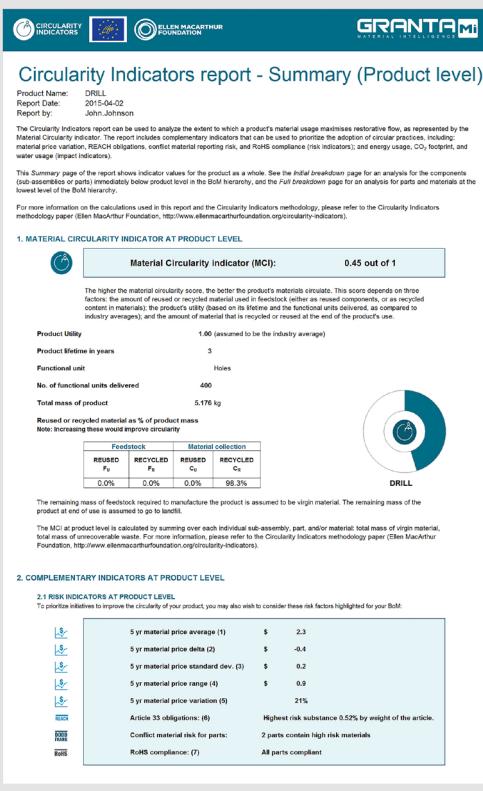
Please visit the Circularity Indicators webpage to download the full methodology and non-technical case studies. <http://www.ellenmacarthurfoundation.org/circularity-indicators/>

If you would like more information on the Webtool please contact: info@grantadesign.com.



(a)

(a) MI:BoM Analyzer — construct or edit a bill of materials and run any of a wide range of reports. An integrated product risk report is shown here.



(b)

(b) Extract of Circularity Report at product level.

Report name	What the report shows
Critical Materials by Element and Part	At-risk elements that may be present in the BoM, with reasons for their risk status
Eco Audit and Comparison Report	Analysis of energy usage, CO ₂ footprint, and end of life treatment for the assembly and its parts
Hazards & Comparison Report	Analysis of RoHS compliance and food-contact compatibility for the assembly and its parts
Obsolescence Risk & Comparison Report	Location within the BoM of substances on the SIN 2.1 list
Obsolescence Risk Comparison	Comparison of substances at risk of obsolescence for 2 BoMs
Product Risk & Comparison Report	Overview of environmental, legislative, and supply risks for the product
REACH Article 33 Declaration, Details and Comparison Reports	Lists substances of very high concern that may be present at more than the regulated amounts
Water Usage & Comparison Report	Analysis of water used in material production for the assembly and its parts

