CIRCULARITY INDICATORS
An Approach to Measuring Circularity

NON-TECHNICAL CASE STUDIES

ELLEN MACARTHUR FOUNDATION

GRANTA MATERIAL INTELLIGENCE

Life

About the Authors

ELLEN MACARTHUR FOUNDATION AND GRANTA DESIGN

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

ELLEN MACARTHUR FOUNDATION

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 MATERIAL INTELLIGENCE

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

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.

More information on the project, including a project overview report and the full methodology, are available for download from the Circularity Indicator Project website:

http://www.ellenmacarthurfoundation.org/circularity-indicators/

In addition, an Excel-based model to illustrate the functioning of the methodology at the product level and a spreadsheet for aggregation at the company level are provided for convenience.

For more information on the Webtool, please contact **info@grantadesign.com**.

Non-Technical Case Studies

This document describes illustrative case studies on how the Circularity Indicators developed in the Circularity Indicators Project can be used. 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 give examples of possible uses, and are inspired by actual examples and real world cases of companies adopting circular economy principles.

THE WIDGET STORE – PRODUCT-LEVEL MATERIAL CIRCULARITY INDICATOR

Comparing the Circularity of Existing Products

Widget Store is a company producing widgets and associated products. They have a range of widgets including a standard product and a premium product.

Sue, the head designer of the company, wants to compare the circularity of *Widget Store*'s products. She therefore chooses a standard product and a premium product and computes their Material Circularity Indicators (MCIs).

To do this, Sue requests bills of material from the relevant product managers, along with information on levels of recycling and reuse and lifetimes for the products:

The **standard widget** is made from ABS[1] plastic (80%) and aluminium (20%). While the plastic is from pure virgin sources, the aluminium supplier tells Sue that they are using recycled input for 50% of the material. Collection data for *Widget Store*'s main markets show that 75% of the aluminium and 25% of the ABS are usually recycled when the widget enters the waste stream. The remainder goes to landfill. The ABS is mixed in with other plastics during the collection process, which results in a low recycling efficiency of 40% for the ABS component compared to 90% for the aluminium component. Sue has access to the latest customer survey that shows that one of *Widget Store*'s standard widgets is usually used for 8 years, while industry-average widgets are used for 10 years.

The **premium widget** is made from aluminium (80%) and ABS (20%). The materials come from the same sources as for the standard product. The recycling collection and efficiency rates are also the same as for the standard widget. The customer survey shows that, due to a higher durability, the average lifetime of the premium product is 12 years.

Using a tool based on the Circularity Indicators methodology, Sue finds that the Material Circularity Indicator of the **standard widget** is **0.06** and that of the **premium widget** is **0.61**. So the premium widget has a substantially higher MCI compared to the standard product due to higher average recycling and better durability.

DESIGNING A NEW CIRCULAR WIDGET

After learning more about the circular economy and circular products and business models, Sue suggests to Maria, the CEO of *Widget Store*, to trial a new widget better leveraging circular economy opportunities. Maria agrees and Sue is tasked with designing the new product. She 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 (86%) and ABS (14%), although it uses less material in total compared to the standard and premium products. All feedstock for newly manufactured product is now 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. This allows for an

1 Acrylonitrile Butadiene Styrene, a common thermoplastic polymer.

increase in the recycling efficiency for the plastic from 40% to 80%. 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**. The increase is mainly due to the high reuse rate and more and more efficient recycling that is enabled by the take-back scheme.

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.

The circular widget reuses aluminium components recovered through the take-back scheme. This saves the significant costs associated with manufacturing new aluminium components and the company finds these savings easily absorb the costs associated with running the take-back process.

The company also incentivises take-back by offering a discount on sales of the circular widget, thus increasing customer loyalty. Alternatively, *Widget Store* offers a rental model whereby the customer can pay a service charge rather than buying the widget outright. Attracted by the inbuilt maintenance arrangements the rental approach has attracted some customers but because it is not a shared ownership scheme it has no effect on the MCI.

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. The CEO of ACME, Marcus, met Maria from Widget Company at a resource management event, where he learned from her about the success of the circular widget. Marcus wants to test this approach with his portable electronic tablet line of products. He asks William, ACME's Chief Tablet Designer, to consider more circular designs, while also considering and not overlooking other business priorities: REACH[2] compliance, carbon footprint, price variation and supply chain risks which are part of ACME's key performance indicators.

William evaluates their typical portable electronic tablet that weighs 0.68 kg, uses 100% virgin materials and is, on average, discarded to landfill after 2 years of use.[3] The tablet has a polymer-based casing and a touch-sensitive front glass covering the LCD display. After careful assessment of the current tablet, William's results highlight that:

- The main contribution to carbon footprint and supply chain risk come from the electronic components.
- The precious and rare earth metals used in the printed circuit board and other electronic components have the highest price variation of the raw materials.

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2 The Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) is a regulation in the European Union, adopted to improve the protection of human health and the environment from the risks that can be posed by chemicals, while enhancing the competitiveness of the EU chemicals industry. It also promotes alternative methods for the hazard assessment of substances in order to reduce the number of tests on animals.

3 In Europe this would usually not be the case, as electronics disposal needs to meet the requirements of the WEEE directive. However, in this illustrative example, this is assumed for simplicity and to highlight the influence of recycled and reused components in the indicators assessment for the redesign options.

- The highest concentrations of substances regulated by REACH are used in the plastics used for the tablet case and the cable insulation.[4] Moreover, due to the presence of a flame retardant, the case cannot be recycled after its use.

Since William knows that in a short time horizon electronic components cannot be easily changed, he focuses his efforts on improving the case and the front glass cover. After sessions with material experts and his design team, he decides to substitute the case material by an aluminium alloy and to modify the design of the screen to allow for easier reuse of the front glass cover. His calculations show that this solution improves the circularity of the product. It also reduces the presence of substances listed under the REACH regulation because the new material avoids the use of the flame retardant that is present in the plastic casing that falls into the REACH Candidate List of Substances of Very High Concern (SVHCs).

The basic characteristics in terms of materials and their origin and destination of the old and new design are given in Table 1.

Table 1: Portable electronic tablet characteristic – baseline and redesign

	Baseline tablet	Redesigned tablet
Bill of materials	• Plastic casing • Front glass cover • Electronic components	• Aluminium casing • Front glass cover • Electronic components
Mass	0.68 kg	0.74 kg
Feedstock materials	100% virgin materials 0% recycled materials 0% reused components	58.3% virgin materials 0% recycled materials 41.7% reused components
Destination after use	100% to landfill 0% to recycling 0% to reuse	58.3% to landfill 0% to recycling 41.7% to reuse

It was highly important for William to review the relevant risks and impacts on the change of design for ACME. The new design delivers a lower proportion of high-risk substances as well as a marginal decrease of its carbon footprint. Although the aluminium used for the case in the new design has a higher carbon footprint compared to the plastic, this is overcompensated by the reuse of the case that decreases the amount of virgin material needed.

A summary of this comparison between the two designs for the Material Circularity Indicator and some of the examined complementary risk and impact indicators can be found in Table 2 below. Calculating the **Material Circularity Indicator** of the **redesigned tablet** gives a value of **0.46** compared to **0.10** for the **baseline version.**

4 Polycarbonate (PC) and polyvinyl chloride (PVC), respectively.

Table 2: Material Circularity Indicator and complementary indicators for the two designs

	Baseline tablet	Redesigned tablet
Material Circularity Indicator	0.10	0.46
Carbon footprint (CO2eq)	20.0 kg	19.6 kg
REACH Article 33 obligations	Highest risk substance 1.3% by weight	Highest risk substance 0.53% by weight
Average annual price variation over the past 5 years	±30% of average price	±30% of average price
Material supply risk – conflict materials	22 parts containing elements with high risk	22 parts containing elements with high risk

THE 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. To kick off this new strategy, they asked Sue to produce a comparative assessment of the various product ranges. Sue uses the company-level methodology to develop her comparative assessment, using sales revenue as the normalising factor, and works together with Kylie, *Widget Store*'s head accountant, to get the relevant revenue data for *Widget Store*'s departments.

In total, the Widgets Department produces two premium widgets, five standard widgets and two circular widgets. In addition to the Widget Department, *Widget Store* has two further departments: a Flange Department that produces a flange that can be used to connect any of the widgets together and an Accessories Department that produces protective covers and cleaning cloths for the widgets.

In the company-level methodology, the *de minimis* rule allows the disregarding of departments in the computation of a company-level MCI when their contribution is below a certain threshold. As the Accessories Department only accounts for 0.6% of total revenue, this division was not considered any further.

Since, for many businesses, it would not be practical to compute a MCI for every single one of their products, the company-level methodology takes a reference product approach where each reference product represents a range of products with similar properties regarding material compositions, recycling and reuse rates, and utility (lifetime and functional units compared to an average product). Sue looks at those characteristics for *Widget Store*'s products and determines that they are quite similar within each range whilst quite different between the various product ranges. Hence she chooses the standard widget, the premium widget and the circular widget examined earlier as reference products. Using the revenue numbers for the different widgets, Kylie combines these MCIs to calculate a **Material Circularity Indicator** of **0.60** for the **Widget Department.**

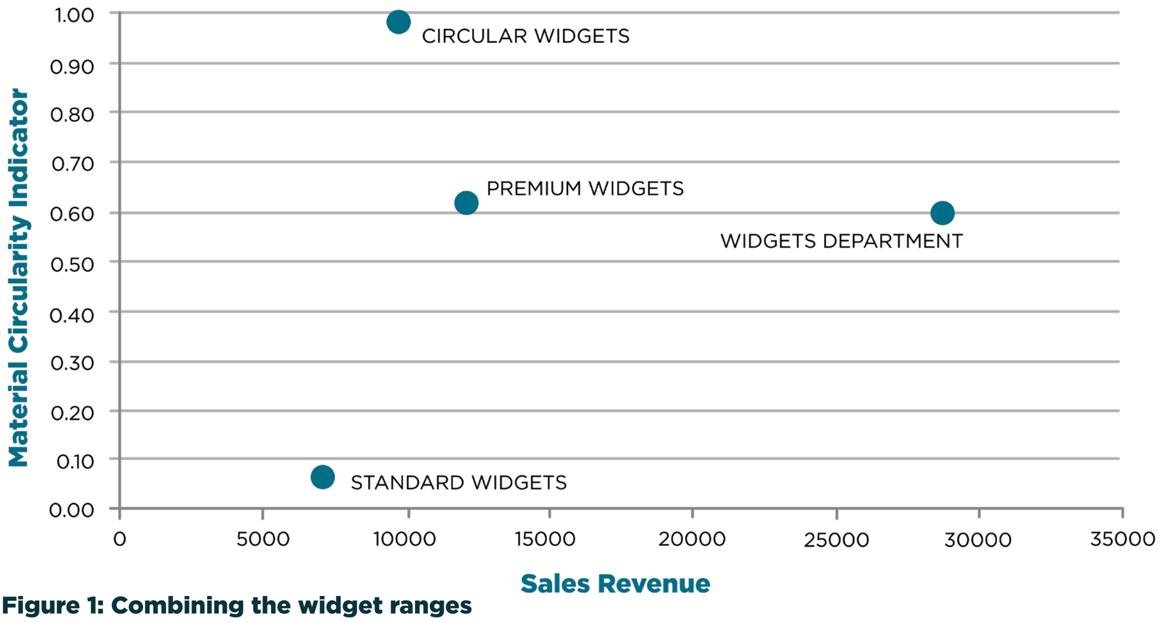

Figure 1: Combining the widget ranges

The Flange Department only contains one product range for which Sue chooses a reference product, so the MCI of this department equals that of this product. Sue uses her product level tool to compute the Material Circularity Indicator of the reference flange as **0.57.**

Using the total revenue numbers of the two departments, Kylie can now calculate the Material Circularity Indicator for the entire company (see Figure 2) as a weighted average. She derives **0.60** as the **MCI for *Widget Store*.**

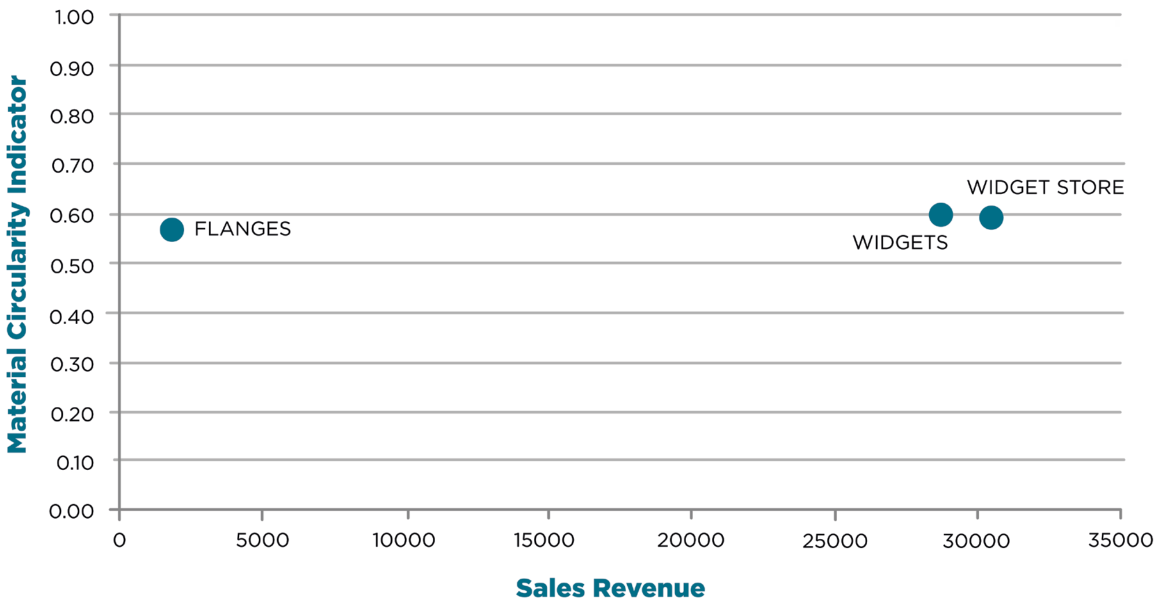

Figure 2: Combining widget and flange departments

Since the main products of *Widget Store* are actually the widgets, it is unsurprising that the resulting Material Circularity Indicator of *Widget Store* is close to that of the Widget Department.

Later that year, *Widget Store* incorporated this analysis in their annual report to shareholders, highlighting the commercial success of their circular widget range. A number of industry analysts were struck by these insights and hence they asked other companies in the sector to disclose similar information. This led to circularity becoming an important competitive issue in the industry.