# Three-Dimensional Product Circularity

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*Understanding product circularity as "three-dimensional" could anchor the Circular Economy to common principles while affording its followers flexibility about how to measure it in their specific contexts. The following position paper explains the three dimensions, and how researchers at RISE (Research Institutes of Sweden AB) are working with industry and government partners to measure them.*

The Circular Economy faces a dilemma. An organization interested in reporting and improving the circularity of its product or service can choose from a growing array of circularity assessment tools. Some organizations may even feel compelled to develop *their own*. The challenge, of course, is that the concept of circularity may lose its power to stimulate societal-scale change if every firm chooses to define circularity in a way most convenient to themselves, yet different from everyone else.

*Sustainable Development* faced a similar dilemma in the 1990s. After appearing in several UN declarations, the sustainability label began to trickle down to national policies, cities, industries, academic programs, and individual products. Keen observers began to voice concern that the concept had unraveled into meaninglessness: *if sustainability was everything, then maybe it was nothing*.

## Some help from urban planners: The Planner's Triangle

In 1996, scholar Scott Campbell helped settle the cacophony for the urban planning discipline by publishing a now classic article describing Sustainable Development as a set of conflicts between three legitimate priorities of urban planning. Achieving Sustainable Development, claimed Campbell, involved continuously resolving the conflicts between 1) environmental protection, 2) economic growth, and 3) social equity. Protecting the environment, for example, might involve imposing clean air standards that (temporarily) limit industrial profits; Growing the economy by building transportation infrastructure might spark a social equity dilemma by harming some neighborhoods while benefiting others; Achieving social equity by increasing the supply of rental housing might harm the local environment by spurring automobile traffic and paving over green spaces. And so on.

By encouraging urban planners to focus on resolving the *conflicts* between the different priorities of urban development, Campbell reframed Sustainable Development as an ongoing process of problem solving instead of an allusive utopian destination. While the "planners triangle" did not completely clear the haze, the scheme was nevertheless useful to urban planners struggling to make sense of the stylish, but dangerously fuzzy concept of sustainability. Business reporting has also adopted a similar multi-priority approach with triple-bottom-line reporting.

## The many meanings of circularity

The concept of circularity and the Circular Economy are experiencing a swell of excitement similar to sustainability's coming-of-age in the mid-1990s. While the two concepts share their roots in environmental movements of the 1960s and 70s, scientific and popular web searches for the term "circular economy" began to accelerate at the end of the first decade of the 2000s, and the first academic article on circularity indicators appears to have been published in 2010.

Recent years have witnessed a small explosion of indicators, metrics, assessment tools, and checklists for circularity. This is due, in part, to the concept's application at multiple levels and by diverse sectors. There are now dozens of ways to verify the extent to which international organizations, nations, cities, businesses, and individual products are more or less "circular."

Michael Saidani and colleagues recently identified 55 different circular economy indicators used around the world, including 20 created to measure product circularity. Many of these have been introduced only since 2017. Their diversity is impressive. Some consider multiple recirculation pathways while others focus on only one (often recycling). Some offer insight on the lifecycle environmental consequences of a product while others focus strictly on the material composition of a product. Some metrics are designed for particular industries while others can apply in multiple contexts. Applying some metrics requires very specific data inputs (yielding relatively precise outputs) while others need only a rough judgement call (yielding rather imprecise outputs).

This proliferation of metrics ought to be welcomed with caution. On one hand, organizations interested in the Circular Economy ought to have access to assessment tools that fit their particular challenges and their particular capacities. An architect calculating the circularity of a building, for example, might benefit from a circularity metric designed specifically for building materials, but shouldn't bother using a tool designed for the Chinese iron and steel industry, or Chinese chemical companies. A startup company just discovering the circular economy might not have the resources to correctly apply a multidimensional metric with complex data inputs, but might find an exploratory metric useful and practical. A firm interested in stimulating reuse and repair through a service-based business model is not best served by applying a metric focused exclusively on material recirculation.

On the other hand, it's important that metrics for the Circular Economy share a backbone so that their application can encourage continuous improvement. How might a company, a government agency, or an organization in general identify the appropriate tool for assessing their progress on circularity without distorting the concept's meaning? How might a service-oriented business that doesn't engage in the manufacturing of goods, measure the circularity of their offer? How might a firm decide between components made of reused or recycled material (a seemingly circular option), and very durable material (also a circular option)?

## *The Three Dimensions: Recirculation, Utilization, Endurance*

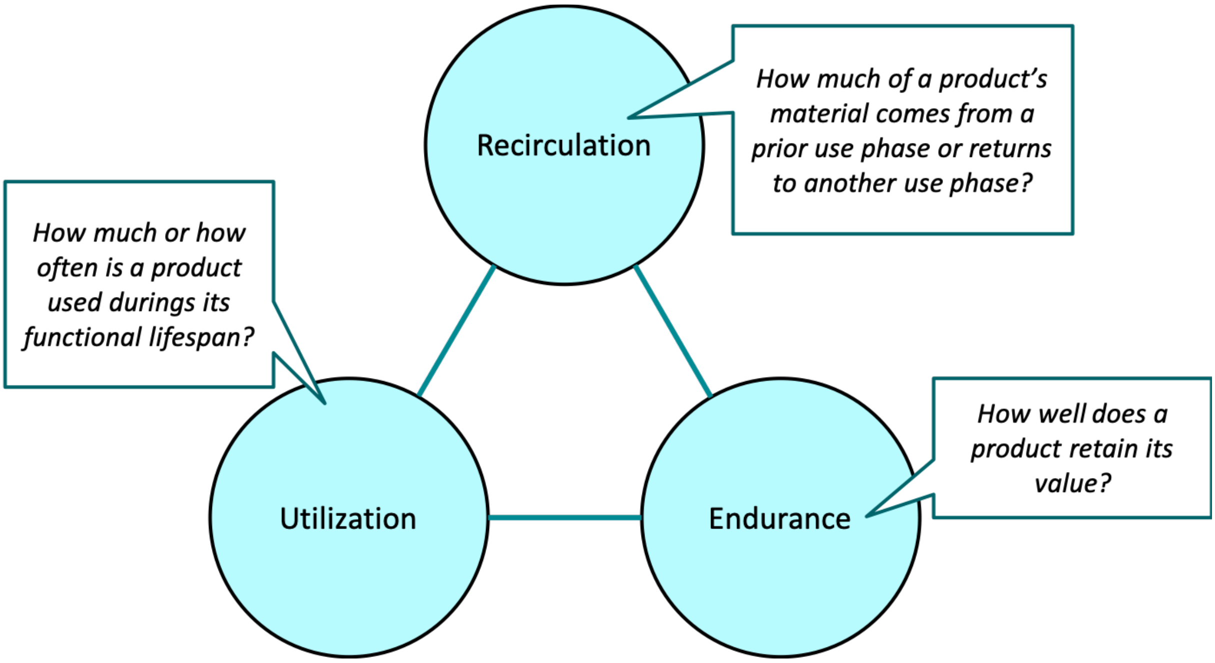
It's perhaps helpful to think of product circularity in three dimensions, similar to Campbell's triangle. The three dimensions include:

1) **material recirculation:** products shall be composed entirely of material recovered from some prior use (e.g. remanufactured or recycled) rather than composed of virgin material
2) **utilization:** products shall be used frequently rather than sitting idly in storage; and
3) **endurance;** products shall retain their value over time, rather than becoming physically degraded or irrelevant (e.g. obsolete).

In short, a product should be made of materials that have been used before. Once created, it should **be used as often as possible**, and it should **remain valuable as long as possible**. It is naïve to believe that all products can maximize all three dimensions. Nevertheless, attempting to maximize all three of these dimensions helps already-extracted resources retain their value while reducing linear throughput.

It is perhaps easiest to understand the importance of each dimension by imagining a product that fulfills two dimensions, but not the third.

- A product made entirely of recycled content (material recirculation) that is used intensely (high utilization) might break down relatively quickly (low endurance);
- A product used intensely (high utilization) without breaking down (high endurance) might demand stronger, newer materials (lower recirculation); and
- A product with high recycled content and high endurance might as well have *never been produced* if it sits in storage without being used (low utilization).




### *Clashing priorities in the linear economy*

In the traditional "linear" economy, where **producers** and **consumers** benefit from the mass production of cheap goods and ownership of a good is typically transferred completely, the three dimensions are in a constant state of conflict. Endurance and recirculation are in conflict because longer-lasting products reduce the supply of recirculated material. At the same time, recirculated material might not have the same durability as virgin material, which reduces endurance. In the linear economy, utilization and endurance are in conflict because a product used very intensively will likely be more costly to restore to its original value. In the linear economy, utilization and recirculation are in conflict because very intensely used products may degrade the quality of recirculated material and make recirculation pathways like reuse and remanufacturing more challenging for manufacturers.

Service-based business models may be the elixir that harmonizes these three dimensions. In a service-based business model or Product Service System (PSS), **service providers** retain ownership of products, and **customers** pay for temporary access to products. Carsharing is a familiar example. Rather than households going into debt to own a machine they have to insure, fuel, store, and repair, they can instead pay for a service that allows them to access a vehicle when they need it, and to return the car when they don't need it or when they're no longer satisfied with it. When a product no longer suits the customer or the service contract expires, the customer returns the product to its source. Therefore the product is *both* enduring *and* reused.

This shift incentivizes the production of high-quality durable goods that are relatively easy to repair. It also incentivizes high intensity use for customers and for service providers: customers don't want to pay for items they're not using, and service providers don't want to pay for unused items. Neither wants to pay for storage. An idealized service-based business model incentivizes constant product use, repair, and upgrade, which can be achieved through future-adaptable design methodologies. This strategy effectively blends all three dimensions of circularity, and is being applied in a growing number of industries.

### *Measuring the Three Dimensions*

While accounting for all three dimensions, it is not necessary for circularity metrics to include all three dimensions. In fact, the convenience of combining all three dimensions into a single metric involves some compromises. The Ellen MacArthur Foundation+ Granta Design Material Circularity Indicator (MCI) addresses all three, but encourages users to measure either utilization or longevity— not both. Additionally, the final MCI score—a single number—conceals whether a product's circularity is due to high rates of recirculation, high longevity, high utilization, or some combination thereof. Among other challenges, the MCI normalizes dimensions of intensity and longevity with industry-specific averages (e.g. estimated longevity relative to all similar products). It is therefore difficult to use the MCI to compare products or businesses in different industries. The CE Indicator Prototype (CEIP) developed by Steve Cayzer and colleagues assesses companies' potential to achieve the three dimensions, but does not assess all three dimensions directly. The Circular Economy Toolkit (CET) developed by Jamie Evans and Nancy Bocken also contemplates all three dimensions, but the tool is better suited as a quick firm-level assessment rather than an objective benchmark.

In many circumstances, it may make sense for an organization to develop a dashboard that includes measurements for each of the three dimensions before combining them into a composite score. Some options are explored below.

#### *Measuring Material Recirculation*

Material recirculation is the most commonly measured dimension of circularity. There are multiple ways to measure it. Metrics can **focus on one or multiple recirculation** pathways like repair, reuse, remanufacturing, or recycling. Metrics can also focus on either recirculated inputs (e.g. how much of my product is made of recirculated stuff), recirculated outputs (how much of my product or my manufacturing waste ends up being recirculated at the end of its functional life), or both. Recirculated "stuff" also has to be measured somehow, for example, in mass or in economic value.

Sustainable Business researchers at RISE (Research Institutes of Sweden) have developed and tested a metric that focuses specifically on material recirculation. The metric, called "C", is determined by the proportion of a product's economic value that comes from recirculated material. Simply expressed, C is equal to the economic value of a product's recirculated material divided by its total economic value. The outcome is a single value, 0 through 1, where a score of 1 represents a product made entirely of recirculated material. RISE researchers have worked with the furniture industry, local-government procurement officers, and the automobile industry to apply the metric. Furthermore, a small-scale test suggests that that there is a clear correlation between high C-scores and low environmental impact, such as climate impact.

### *Measuring Utilization*

Measuring utilization is comparably **less common**. A measure for utility inquires how often a product gets used. An intensely-used product can be thought of as *earning* the energy and resources required to produce the product in the first place. A car driven many miles in a short period of time demands fewer resources per kilometer driven than a car that spends 99 percent of the day parked. Such a vehicle is also less likely to decay or age into irrelevance.

The MCI (discussed above) integrates utilization by dividing an individual product's estimated lifetime functional units by an industry average number of functional units. For example, a car designed to drive 20,000 km per year when the industry average is 14,000 km would have a utilization rate of 1.43 (20000/14000 = 1.43). This number is plugged into a more complex formula to arrive at one component of the MCI. Of course, it can be challenging to correctly predict functional units for an individual product. The metric also offers no guidance about how to pick the appropriate industry average. Is it best, for example, to compare a car's distance traveled to all other cars in the same country? To cars of the same class? To cars from the same product line?

Measuring utilization is also much easier for products that are easily understood as being *used*. For example, it is relatively easy to measure how much or how often cars, computers, washing machines, power drills, lighting fixtures, and clothing get used. However, it's more challenging to identify how often or how much passive objects like a window, a poster, a street sign, or a houseplant get used. Measuring utilization may require that certain products be considered as components of larger assemblies of products, and this may require communication across sectors or new business models to understand segregated products as part of a product package.

RISE Sustainable Business researchers are considering metrics for utilization based on changes in economic value. The "U" metric is defined by the proportion of a product's change in economic value due to being used, rather than age or external changes in the market. A washing machine that has been run very intensely because it is serving multiple households will have lost relatively more of its market value due to being used rather than decaying or being edged out of market relevance by a more efficient market alternative. This metric works particularly well for products with measurable use and requires comparisons across a sample of other products. More passive products or assemblages of products like interior spaces could be measured as users per unit of space per unit of time (persons per square meter, per hour). These are both still experimental applications.

### *Measuring Endurance*

There are intuitive reasons to measure endurance as a dimension of circularity. A product that retains its value for a long time represents one less product manufactured, fewer resources extracted, and less waste generated. Products can endure because they are better built or perhaps designed to outlast changes in taste or style. As an independent dimension of circularity, however, it remains the least often measured. Multiple assessment tools include subjective questions related to product durability, but such a feature is challenging to normalize in an objective way. The MCI handles endurance similarly to utility, by dividing a product's estimated lifetime by an industry average, for example estimated lifespan of a hammer divided by the industry average lifespan for hammers. The shortcomings of this approach are very similar to the shortcomings of the MCI's utility measure: it's difficult to predict how long any single product will be used, and there is no guidance about how to determine the appropriate industry average for comparison.

Researchers at Kedge Business School (France) have developed a longevity indicator that uses units of time to show how pathways of recirculation add to the lifespan of material within a product line. Reuse, refabrication, and recycling elongate the functional lifespan of material. The longevity indicator expresses this in months or years added. Such an indicator might be useful for comparing a product line's level of material recirculation before and after strategic changes within a firm. It could also be useful as way to compare the lifespan of similar product lines in different firms, provided one could access the requisite data from each firm. Yet, despite being expressed in units of time this metric is primarily an indicator of material recirculation as it only indirectly rewards long-lasting products by accounting for its initial use phase.

RISE Sustainable Business researchers have begun to develop a Market Entropy (ME) metric that is determined by the cost of restoring a product to its original market value. It is expressed as one minus a ratio of

a) the total cost of the utility of a product (i.e. the cost of maintaining, repairing, refurbishing a product and delivering a product's utility) in some random period of time, to;
b) the total value of the utility of a product, measured in sales revenue.

In short, a product that is cheap to maintain at its market value is rewarded with a higher, better score. Such a metric encourages long-lasting, high-quality products that are inexpensive to repair. It also encourages future-adaptive design of products, so that products can in fact improve with time.

### *Measuring Circularity and RISE Sustainable Business*

What do the circularity metrics developed by RISE Sustainable Business have in common? One common thread (or "red thread" as the Swedes say) is value retention. A product that holds on to its economic value *despite* being made of already-used material, *despite* being used frequently, and *despite* its old age, is more circular. This can be enhanced by product design, by more conscious material selection, by business model innovation that removes incentives for idle capacity, and by more mindful users. Secondly, the three metrics discussed above all focus exclusively on a single dimension of circularity without attempting to combine them into a composite score. While there are some conveniences to expressing circularity as a single score—it's easier for rankings, for example—such a score might conceal the inner workings of a product's pathway to circularity. A dashboard of dimensions can reveal specific opportunities for improving product circularity and leave conversations about policy more open to diverse strategies and stakeholder dialogue.

Organizations interested in achieving circularity ought to seek to maximize all three dimensions for their products and services, and use the conflicts between them as clear signals that there is an opportunity for innovation.

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