MEASURING CIRCULARITY FOR CAPITAL EQUIPMENT

Gaps, challenges and recommendations for an evolving metrics landscape

July 2022

PACE
PLATFORM FOR ACCELERATING THE CIRCULAR ECONOMY

U.S. Chamber of Commerce Foundation

CIRCLE ECONOMY

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We are a global impact organisation with an international team of passionate experts based in Amsterdam. We empower businesses, cities and nations with practical and scalable solutions to put the circular economy into action. Our vision is an economic system that ensures the planet and all people can thrive. To avoid climate breakdown, our goal is to double global circularity by 2032.

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This report is published as an affiliate project of the Platform for Accelerating the Circular Economy (PACE). PACE is a global community of leaders, across business, government and civil society, working together to develop a collective agenda and drive ambitious action to accelerate the transition to a circular economy. It was initiated at the World Economic Forum and is currently hosted by the World Resources Institute.

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EXECUTIVE SUMMARY

The circular economy is a means to an end.

Against the backdrop of climate breakdown, emissions and material use are continuing to spiral—contributing to a world that is only 8.6% circular. Nearly three-quarters of emissions stem from material use and handling. Applied globally, circular strategies that optimise resource use and reduce consumption rates can slash emissions by 39% and get us on track to reach the 1.5-degree target.[1] The circular economy is a systemic transformation that designs out waste, preserves material value and regenerates nature: it is essential to meeting our end goal of a safe and just operating space for the planet.

Metrics and data are crucial to driving the transition.

To stem the worst impacts of climate breakdown, the capital equipment industry aims to double global circularity by 2032. But if we don't measure, we can't track progress in an actionable way that determines how and where we need to step up to make the most impactful changes. Metrics for circularity are under development by businesses, the EU and international organisations alike, to help companies jump-start their circular journeys and inform decision-making. Capital equipment companies are especially attuned to the need for circular metrics. The industry collectively consumes more than seven billion tonnes of materials a year to create long-lasting products with high potential for circularity.[2] But while existing circular metrics frameworks provide a range of indicators—from material flows to water and energy use—the gaps that remain are an opportunity for framework developers to collaborate and align with the needs of the capital equipment industry.

How can we measure value intensity and lifetime extension?

Value intensity—maximising value with minimal material input—and lifetime extension are key concepts for the circular economy, yet they are complex and difficult to measure. Manufacturers have little influence on how products are used by customers; and for the capital equipment industry in particular, value intensity is closely interlinked with equipment uptime. And what's more, current circular indicators—such as those for revenue, inflow and outflow—don't assess the use phase of a product, which means value intensity and lifetime extension strategies go largely uncaptured.

How can we measure avoided impact?

Strategies that maximise value intensity, such as servitisation, or extend product lifetimes, like predictive maintenance, will likely result in avoided impact—from using fewer materials and/or emitting less CO2. Measuring this, however, requires setting a baseline to quantify the avoided impact of what has been optimised, such as material savings. This varies in complexity at the product, system or infrastructure level due to constraints on data availability. Early adopters of circular design strategies may also appear 'less circular' under certain indicators, which measure performance improvements over time rather than present a final result or score that accounts for avoided impact. For other frameworks, which assess absolute metrics rather than relative changes, this does not apply.

How can we measure the impact of Everythingas-a-Service (XaaS) systems?

Currently, there is no standardised approach to account for material flows within a XaaS model where equipment manufacturers and/or service providers retain ownership and provide customers with access. This is particularly relevant for capital equipment companies that are already using servitisation to achieve the inherent positive circular impact of value intensity, lifetime extension and avoided impact.

Measuring different factors and perspectives.

Operationalising circular strategies involves a range of actors across the value chain that must be accounted for to accurately attribute impact. Circular metrics frameworks that set clear measurement boundaries, whether at the product or system level, will help companies pinpoint the improvements needed to increase their circularity performance. Furthermore, since there are multiple, standalone factors that can directly influence circular performance, such as digitalisation, servitisation and product design, standalone indicators may be needed to represent these factors that are standardised across frameworks.

No time to lose: we all have a role to play in advancing circular metrics

Circular metrics are critical to scaling circularity in the capital equipment industry and beyond. We urge framework developers to consider and address the gaps illustrated by this paper to better support capital equipment companies in their circular journeys. Likewise, we urge capital equipment companies to start measuring their circularity now to drive positive impact and accelerate the transition to a circular economy. Finally, we encourage the public and private sector organisations that have independently advanced circular metrics to collaborate and converge on a harmonised framework.

Let's work together to activate circular solutions and close the Circularity Gap for everyone.

It is time for collective action to reset our global economy to be in service to people and the planet. As the world's attention turns toward COP27 and nations rush to update their climate pledges, let's commit to activating the critical solutions that circularity offers to help both countries and businesses meet their climate goals, safeguard the Earth's resources and protect all people. It's time for a circular economy.

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1. Circle Economy. (2021). *The circularity gap report 2021* (pp. 1-71, Rep.). Amsterdam: Circle Economy. Retrieved from: CGRi website
2. Circle Economy. (2020). *The circularity gap report 2020* (pp. 1-64, Rep.). Amsterdam: Circle Economy. Retrieved from: CGRi website

1. INTRODUCTION

Since their emergence from academia into the mainstream, circular economy principles are increasingly being recognised by civil society and public and private sectors as a means for achieving sustainability goals and mitigating the worst impacts of the climate crisis. However, ensuring that sustainability ambitions are achieved as part of a circular transition will require the development and adoption of a harmonised measurement framework that assesses the economic, environmental and social impacts of circular strategies at a company, industry and even national and global level.

Metrics for the circular economy

Circular economy thought leaders at the company level, the EU level and internationally have developed several circular metrics frameworks. The World Business Council for Sustainable Development (WBCSD) and the Ellen MacArthur Foundation (EMF), for example, have each established frameworks underpinned by key circular metrics. Companies across diverse sectors have begun using the WBCSD's Circular Transition Indicators (CTI) and EMF's Circulytics to benchmark their performance on circular material flows, circular revenue, water and energy circularity and product recovery to drive internal decision making and continuous improvement.

While these frameworks have generated growing consensus on which quantitative indicators best measure overall circularity performance, the capital equipment industry has identified several metrics gaps and data challenges that are also applicable to other industries working towards scaling their circular ambitions. This paper will provide a summary comparison of the CTI and Circulytics indicators followed by an analysis of three critical gaps to be addressed in future frameworks: (1) Value intensity and lifetime extension; (2) Avoided impact; and (3) Capturing the impact of Everything as-a-Service (XaaS).

Please note that the following table comparing CTI and Circulytics is not exhaustive and does not cover all indicators included within each framework.

INDICATOR	CTI	CIRCULYTICS
Scope	The metric can be assessed on multiple levels: from the broader company level to the more narrow business unit, production facility, and product (group) level.	The recommended scope of the assessment is aligned with the Greenhouse Gas (GHG) protocol definition of company boundaries, but can be customised for a purely internal assessment.
Circular material flows: The proportions of materials flowing in and out of a business as it carries out its regular operations that are circular.	CTI's circularity metric, presented as a single figure, represents a weighted average of circular inflows and outflows in terms of mass—in other words, it measures material circularity as a percentage. Circular inflow is quantified based on the content of sustainably sourced, biobased and/or cycled material content for inputs; conversely, outflow is quantified based on rates of recycling and other recovery strategies (remanufacturing, for example), based on primary data and national statistics for the relevant materials.	An overall score for products and materials, derived from indicators based on the total annual mass of all material inflows and outflows. Circular inflow is based on the content of secondary or sustainable/regenerative material, while outflow measures the actual recirculation of waste and products (see final row). Flows are split into products designed to be 1) consumed, or 2) used, and outflow is divided into waste streams and product outflows.
Circular revenue: A measure of the proportion of a company's revenue that stems from circular offerings.	A company's CTI revenue is its revenue adjusted for the percentage circularity of its product portfolio. Once this figure is calculated for all products, it is possible to derive the total circular revenue value—and percentage of total revenue—for the company as a whole. The calculation is based on the weight of material flows, and so does not adequately capture the impact of digital solutions. However, dematerialisation is still reflected through the Circular Material Productivity indicator.	Revenue is used to assess the circularity of services. Circular service revenue is defined as the percentage of revenue earned from circular services. (Products and materials are assessed in terms of mass, not revenue.)

INDICATOR	CTI	CIRCULYTICS
Energy circularity: The proportion of a company's energy supply that comes from renewable sources.	The metric for Renewable Energy is a simple calculation: $\frac{\textit{enewable energy consumption}}{\textit{Total energy consumption}}$ This is calculated based on annual figures and expressed as a percentage.	As in CTI, Circulytics requires the percentage of energy—heat, electricity and fuel—that the company consumes that comes from renewable sources. For energy producers the same logic is applied for energy that the company produces.
Water circularity: A measurement of the degree to which freshwater is circulated within its local or regional catchment or watershed.	CTI measures water circularity by averaging the percentage of circular water inflow and percentage of circular water outflow—both of which depend on local water conditions. The framework also provides an internally-facing metric that calculates onsite water circulation, such as water reuse and recycling.	Circulytics calculates water circularity based on inflows and outflows. Onsite water circulation is considered a circular inflow. Assessing the need for reduction targets and nutrient recirculation are further components of the water score in this metric.
Product recirculation: Keeping products and materials in the economy at end-of-use is an important component of circularity.	CTI presents a metric that shows the percentage of each recovery option, enabling companies to deeply explore which products are more subject to higher value recovery and which aren't.	Circulytics requires that companies report the means by which products and materials are circulated—reuse/ redistribution, refurbishment/ remanufacture, recycling, and nutrient recirculation—as a percentage of mass. Higher-value loops are the preferred option.

2. EVOLVING METRICS LANDSCAPE AND GAPS

Metrics that measure material flows, water and energy use, circular revenue and product recovery enable most companies to jump-start their circular journeys, track progress and inform decision making. This is especially critical for capital equipment companies, which have a key role to play in the circular transition.

> The capital equipment industry has strong potential for resource-efficient value creation.

The capital equipment industry's high environmental impact and upfront costs incentivise the design and manufacture of equipment that's built to last and be reused.[3] However, to harness capital equipment's circular potential, stronger alignment is needed with circular metrics frameworks to ensure outcomes and performance improvements can be measured accurately over time.

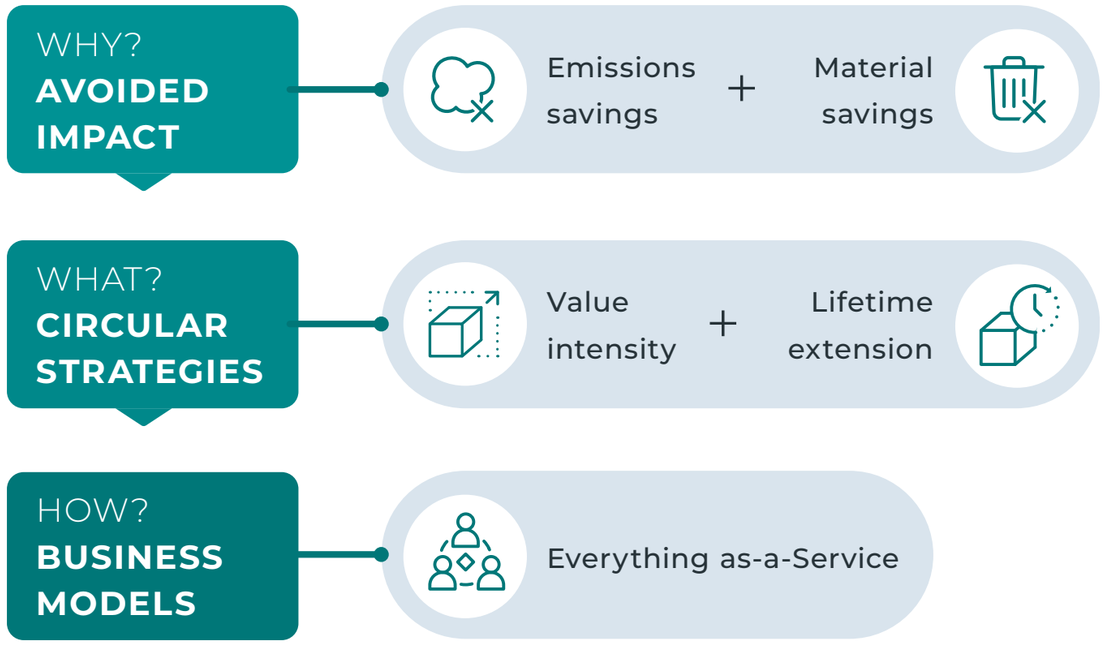


Figure one: an overview of some of the essential circularity characteristics to be measured in the capital equipment industry

3. Platform for Accelerating the Circular Economy (PACE). (2021). *Circular economy action agenda working paper: Capital equipment* (pp. 1-46, Rep.). Amsterdam: PACE and Circle Economy. Retrieved from: PACE website

This section outlines the need for circular indicators that measure specific facets important for capital equipment companies. These include: 1) Value intensity and lifetime extension; 2) Avoided impact and 3) Capturing the impact of Everything-as-a-Service (XaaS).

1. VALUE INTENSITY AND LIFETIME EXTENSION

Current understanding of value intensity and lifetime extension

The objective of **value intensity**, a key concept in the circular economy, is to maximise value with minimal material inflow. The most common approach for maximising value is to maintain high utilisation rates over the technical lifetime of a physical product or system. This can be achieved through servitisation approaches, known as XaaS business models. Lifetime extension is a circular strategy intended to support high utilisation rates through remote diagnostics, predictive maintenance, upgrades and advanced repair technologies. Manufacturers may also apply lifetime extension strategies during the design phase to improve durability, and at the end of each use cycle to support repair and refurbishment. Similarly, original equipment manufacturers (OEMs) can design hardware with enhanced capacity and functionality to simultaneously boost value intensity and reduce demand for new products. For instance, in health technology, introducing functional enhancements to an MRI machine can increase the accuracy of its scans and as a result reduce the number of scans needed per patient, thereby reducing overall demand on the machine. Digitalisation has also emerged as an approach to optimise value intensity by using less hardware and fewer materials to deliver the same outcome or even improve performance.

Difficulties measuring value intensity and lifetime extension

Measuring value intensity and lifetime extension are both complex processes with multiple facets to consider. Assessing value intensity, for example, yields different results when comparing a finished product to a piece of equipment used in a production process—yet clear definitions and calculations for this are lacking. These concepts are also particularly difficult to measure due to manufacturers' lack of influence over how often products are used by customers.

> Value intensity is closely tied to equipment uptime, which is the amount of time equipment is in operation or allocated for use.

To influence higher utilisation rates, manufacturers can shift to servitisation or digitalisation business models that drive uptime efficiencies and optimal usage through remote monitoring and scheduling. Customers will have an important role to play in encouraging this shift. Other companies, such as financiers and third-party service providers can facilitate lifetime extension and high utilisation through servitised product offerings and by financing and facilitating the repair, refurbishment and redeployment of assets.

Although the majority of value intensity occurs at the use phase, indicators for revenue, inflow and outflow in current circular frameworks do not assess use phase activities. As a result, strategies such as lifetime extension, which can be effective at boosting value intensity during the use phase, are not explicitly measured and scored. For example, using a piece of equipment more intensively and/or for a longer period of time, may be calculated by current frameworks as a decrease in circular inflow for the same amount of revenue, resulting in an overall lower score on circularity.

There are also challenges with scoping and reporting value intensity. For example, it is unclear whether an OEM who maintains ownership of capital equipment while in use by the customer, should report the equipment as Outflow or maintain it on their balance sheet. Both options present issues: if the equipment is reported as Outflow the Percentage circular outflow will drop temporarily until recovery at end of use, while if it remains on the balance sheet, it will not be measured by the overall circularity (or headline) indicators. Furthermore, OEMs that supply on-premise equipment to their customers often have limited access to the utilisation data needed to measure and optimise value intensity.

2. AVOIDED IMPACT

Current understanding of avoided impact

Avoided impact is another crucial concept for the circular economy which is applicable to different products, sectors and industries. It can also be an important outcome of value intensity, lifetime extension and XaaS strategies.

Refusing and reducing the use of materials rank highest on the waste management hierarchy and are core to avoiding both waste and carbon emissions that result from material extraction. There are several circular design strategies, such as dematerialisation and digitalisation, that support avoided impact by cutting material use in the manufacturing phase or by replacing material-intensive hardware with digital solutions. For example, Philips' Lumify software runs on existing generic hardware, such as a tablet or phone, which cuts demand for specialised hardware, such as a patient monitor. Damen's solution Triton allows for the remote monitoring of their vessels' systems and operation so that the company can advise clients on how best to maintain value and avoid issues that may surface. In the future, this could open new avenues for 'digital twins'—virtual models that reflect the properties of a physical product—to conduct predictive maintenance. Avoided impact may also occur in a broader sense, not directly related to product development: agricultural machine manufacturer Lely, for example, indirectly cuts fossil fuel use by transforming nitrogen into circular fertiliser on-farm, decreasing the need for emissions-intensive chemical fertilisers.

Difficulties measuring avoided impact

As strategies to boost avoided impact gain traction, several challenges around measurement have surfaced. First, like lifetime extension, measuring avoided impact requires setting a baseline on a reference product or system to quantify the avoided impact of what has been optimised. While this has been done for carbon emissions at the product level, it is particularly challenging at a system or infrastructure level due to difficulties obtaining data to calculate material savings and translate them into avoided impact. For example, Philips' telehealth solutions enable patients to be monitored and diagnosed at home instead of at a hospital—which helps prevent emissions from transportation, hospital building infrastructure and even the use of onsite consumables and equipment. However, it is very challenging to obtain standardised data that quantifies overall material savings and links them to avoided impact through fewer kilometres travelled or a smaller hospital buildings, for example. Similarly, Damen is making strides to boost material efficiency by cutting paint use and steel plate thickness—but current frameworks don't facilitate impact measurements for these improvements.

Also, early adopters of circular design strategies that have already optimised their product portfolio through dematerialisation and/or digitalisation are unlikely to realise significant avoided impact gains when compared to their baseline over time—and may find further changes increasingly expensive. If an indicator focuses on improvement or change rather than the final result or score, firms that took proactive steps prior to widespread measuring could appear to be making less progress. Finally, benchmarking avoided impact across the capital equipment industry will prove difficult due to the different regions and markets in which companies operate.

3. CAPTURING THE IMPACT OF EVERYTHING-AS-A-SERVICE

Current understanding of capturing impact from Everything-as-a-Service

One-time transactional sales are a hallmark of the linear economy: once a customer owns a product, producers are no longer responsible for what happens to it—and what's more, they benefit from selling as much as possible. XaaS systems present an alternative, where the OEM retains ownership of its equipment and offers customers access to use it through subscription models and bundled services. By retaining ownership, OEMs are incentivised to boost the lifetime and value intensity of their equipment, which can result in avoided impact over time.

> XaaS can be a good indicator of circularity, but measuring its impact remains a challenge.

Difficulties measuring and attributing impact of XaaS

In most XaaS models, OEMs retain ownership and outsource services, such as take-back and refurbishment, to third-party providers. Increasingly, manufacturers, service providers and XaaS customers want to quantify the avoided impact of XaaS compared to linear systems.

Yet, measuring and attributing avoided impact to the appropriate company in the value chain remains a challenge. For example, there is no standardised approach for measuring and attributing material flows resulting from XaaS services that extend product lifetime, such as repairs and upgrades.

Furthermore, like dematerialisation and digitalisation, measuring the avoided impact of XaaS strategies requires setting a baseline and having access to standardised data. In addition, specialised service providers that support OEMs' XaaS offerings may be challenged to demonstrate significant avoided impact gains over time.

Similarly, as with value intensity and lifetime extension, it is challenging to accurately scope the impact reporting boundaries of on-premise equipment sold in an XaaS model. For example, if it is reported by the OEM as circular Outflow, then the Percentage of circular outflow will drop temporarily until recovery at end of first useful life. At the same time, if it remains on the OEM's balance sheet, it will be excluded by circularity headline indicators and could drag down aggregate circularity scores based on larger 'umbrella' indicators.

While avoided impact can be a positive outcome of XaaS systems, metrics frameworks may need to develop a qualitative indicator that represents a company's circular contribution in its overall circularity score.

3. IMPLEMENTATION **CHALLENGES**

Even as metrics frameworks evolve to support the circular imperative of the capital equipment industry, several key data-related challenges could continue to hinder companies' implementation of circular metrics at scale: 1) Data availability and transparency; 2) Utilisation data and privacy; and 3) Product grouping and variability.

> Data sharing across the value chain will be critical to scale implementation of circular metrics.

Data availability and transparency

Some calculations that underpin circular metrics require the use of best-in-class industry benchmarks, that are underpinned by companies' product-level data. Yet, consistent access to product-level data can be challenging for many companies with vast supply chains. Often, supplier data at the material, component or product level is incomplete or considered proprietary. To work around these constraints, companies may opt to use global averages or proxy data to calculate material flows and avoided impact, which can dilute the accuracy of industry benchmarks, as well as the baselines companies set internally to make relative impact comparisons.

Utilisation data and privacy

Maintaining high utilisation of equipment through lifetime extension strategies and XaaS models can drive maximum value with minimal resources. However, tracking usage and performance across the equipment's technical lifetime requires continuous data capture which can present multiple challenges. As a result, some companies may opt to use more readily available financial or transactional data to represent utilisation which can dilute accuracy and distort impact. For example, the volume of rental or XaaS transactions per asset is often used as a proxy for utilisation even though transactional data is not consistently correlated with utilisation. This can result in an artificial boost to utilisation rates when sales volumes are high.

In addition, data privacy regulations may require companies to wipe usage data from equipment before transferring it to the next customer. However, this may be addressed by anonymising usage data since customer-identifying details are not required to measure utilisation rates.

Product grouping and variability

Currently, some capital equipment assets are managed at the group or category level, rather than at the individual product level. This can result in average relative comparisons which may, in turn, dilute or even misrepresent the performance and impact of a company's circular strategies. DLL, for example, generally tracks average useful life per product category rather than for individual assets since the monitoring needed is not available in all markets. Other companies have observed data gaps that surface as a result of product customisation and implementation which can hinder accurate product comparisons over time. To illustrate, Vanderlande has reported that product implementation varies from customer to customer, which renders generalisations among products of the same type inaccurate. Thus, managing assets on a group level can hinder meaningful insights.

4. KEY TAKEAWAYS AND NEXT STEPS

The World Business Council for Sustainable Development's CTI and the Ellen MacArthur Foundation's Circulytics frameworks have laid important groundwork for the capital equipment industry to start measuring and optimising its circularity. Maturing these frameworks to support measurement of value intensity, lifetime extension, avoided impact and XaaS models will be important enablers for companies to scale up their implementation of circular metrics. This will require continued collaboration among companies and framework developers to evolve key indicators as well as standardise commonly accepted definitions and terminology. Doing so can drive more effective industry benchmarking, improve data transparency and surface new value propositions for companies eager to start or grow their circular ambitions.

Several key takeaways have emerged as a result of exploring the current circular metrics landscape.

First, operationalising circular strategies, such as XaaS and access-based business models, involves a range of actors and activities across the value chain, from suppliers and manufacturers to service providers and reverse logistics partners. Their collective and individual impacts must be measurable and attributable at the product and/or company level in order to pinpoint opportunities for improvement. Circular metrics frameworks can be a powerful tool to support this by bringing visibility to the greatest impacts and where they exist in the value chain.

Secondly, there are multiple factors that directly influence circularity and should be accounted for by circular metrics, including digitalisation, servitisation and product design for modularity, repairability, disassembly and reuse. Each of these factors play an important role in optimising and increasing circularity either actively, by extending product lifetimes, or passively, by reducing material inflows. Hence, frameworks may need to consider them as standalone indicators rather than as indirect contributors or enablers. Finally, due to multiple value chain actors and factors that directly influence circularity, setting the appropriate boundaries for measurement can be challenging at the individual product level. To reduce some of this complexity, frameworks should also support measurement at the product group or category level.

> Maturing frameworks will require collaboration among companies and frameworks developers to evolve key indicators and standardise definitions.

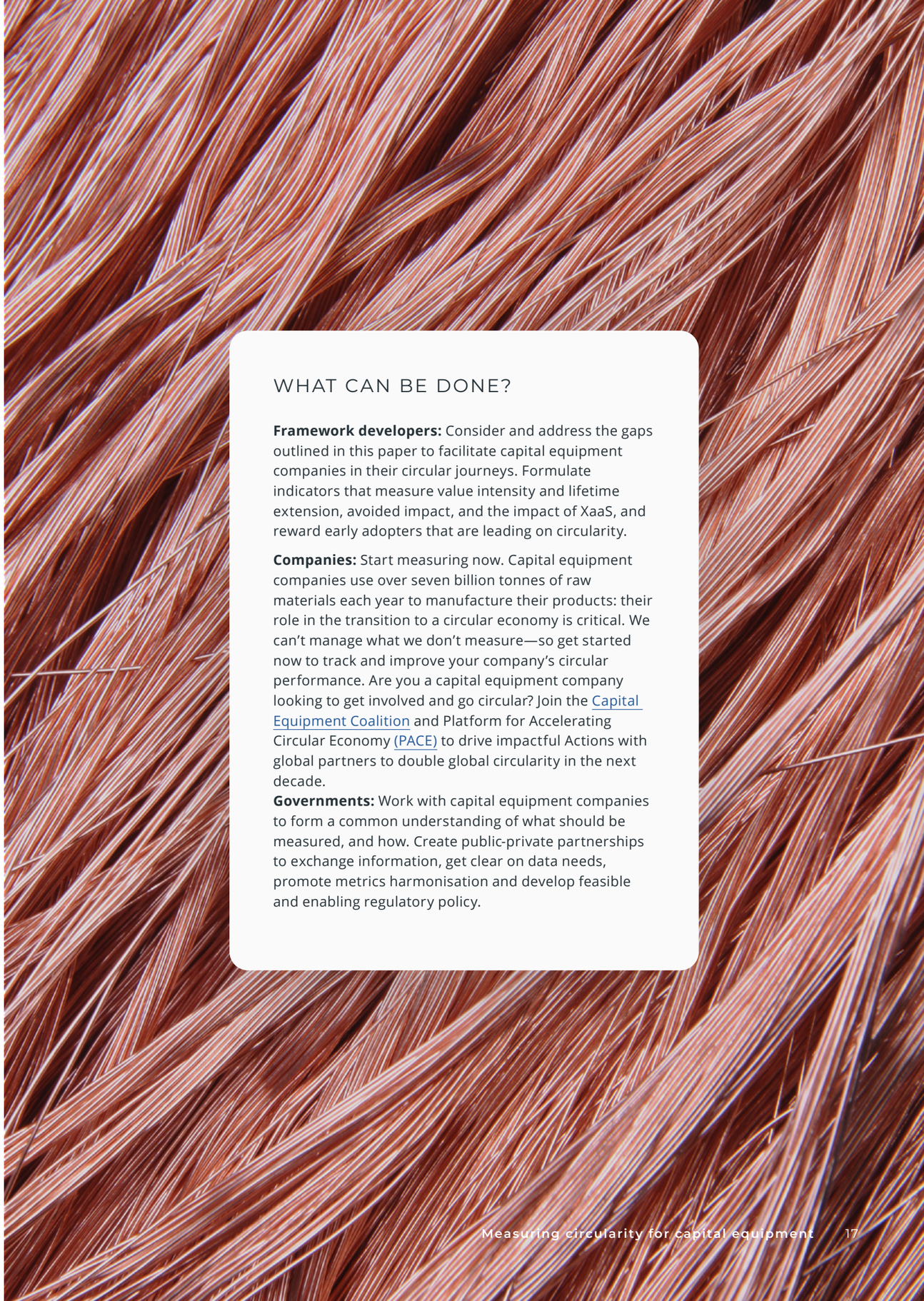
In addition to capturing the multi-dimensional nature of circularity, metrics frameworks must also consider the following impact measurement principles:

1. **Standardise terminology and definitions.** Strengthening and standardising the terminology and definitions that underpin circular indicators will not only deepen understanding for companies starting out on their circular journeys, but will also help to broaden companies' adoption and operationalisation of metrics frameworks. Furthermore, harmonising definitions with existing global standards, such as ISO, will ensure that new and evolving circular metrics indicators remain well aligned.

2. **Set specific, quantifiable baselines for relative comparisons.** Encouraging companies to define clear boundaries and specific baselines will help generate more accurate results for relative comparisons at the product or company level. While 'best-in-class' baselines are often used as a proxy for benchmarking, over-reliance on relative comparisons could misrepresent circular performance.

3. **Data availability and quality remains an issue.** As is common for metrics in general, data is needed to quantify circular performance—yet frameworks often require data that is not being collected, or is of low quality. Data minimisation should be applied where possible.

The transition to a circular economy is critical to stem the worst impacts of climate breakdown—and the advancement and adoption of circular metrics plays a key role. The capital equipment industry calls on metrics framework developers, companies and governments to collaborate and align to achieve the ambition of doubling global circularity within the next decade.



WHAT CAN BE DONE?

Framework developers: Consider and address the gaps outlined in this paper to facilitate capital equipment companies in their circular journeys. Formulate indicators that measure value intensity and lifetime extension, avoided impact, and the impact of XaaS, and reward early adopters that are leading on circularity.

Companies: Start measuring now. Capital equipment companies use over seven billion tonnes of raw materials each year to manufacture their products: their role in the transition to a circular economy is critical. We can't manage what we don't measure—so get started now to track and improve your company's circular performance. Are you a capital equipment company looking to get involved and go circular? Join the Capital Equipment Coalition and Platform for Accelerating Circular Economy (PACE) to drive impactful Actions with global partners to double global circularity in the next decade.

Governments: Work with capital equipment companies to form a common understanding of what should be measured, and how. Create public-private partnerships to exchange information, get clear on data needs, promote metrics harmonisation and develop feasible and enabling regulatory policy.

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