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The Servitization Revolution for Sustainability

Nicola Sacconi, Federico Adrodegari,
Mario Rapaccini, Laura Scalvini

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ASAP

RESEARCH CENTER



THE **SERVITIZATION** **REVOLUTION** FOR **SUSTAINABILITY**



THE SERVITIZATION REVOLUTION FOR SUSTAINABILITY



The ASAP research centre on service management and innovation in industrial firms

ASAP is the Italian "Interuniversity Research Centre on Service Innovation and Management in Industrial Enterprises-ASAP SMF", founded by the Universities of Bergamo, Brescia, Florence, and Eastern Piedmont. ASAP is among the reference research institutions at the European level on the subjects of servitization, service business and service operations management. It carries out research, training, workshops, and conferences, and promotes networking and dissemination.

In the ASAP Community, university research groups and companies collaborate for innovating service design and management, and change management for the strategic development of the "service business".

In particular, the Center aims to:

- promote, organize and carry out scientific research activities and projects in the broad domain of "servitization" (innovation through services in industrial enterprises);
- disseminate the results of research activities through events, conferences, workshops, and webinars to facilitate the meeting between the world of research and the world of business;
- foster, by collaborating with innovation ecosystems and university spin-offs, processes of innovation and technology transfer to companies;
- encourage the opening of internship positions for trainees, students, graduates, doctoral students, and research associates of the Universities involved, within the institutions, and companies that collaborate with the centre;
- develop and deliver academic training projects;
- participate, providing qualified teaching, in corporate training projects commissioned by enterprises and external partners;
- foster the development of collaborations with the most active research groups, on an international level, on the topics of interest, in particular through the International Scientific Advisory Board of the research centre (<https://www.asapsmf.org/en/network-and-collaborations>);
- foster contact and exchanges with local and national public institutions to prepare regulatory and industrial policy instruments on issues in the domain of interest.

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Executive summary

Due to increasing concerns about climate change, overexploitation of the earth's finite resources, raw material extraction, increasing waste, and pollution, there is an urgent need to shift to economic models that guarantee environmental sustainability.

Servitization proposes a paradigm shift of business models that increase value creation for the customers by changing the perspective: from the making of products and the transfer of ownership, to the provision of integrated solutions enabled by those products, through lifecycle services. This paradigm shift also responds to the call for environmentally sustainable business models, as the move to a performance economy (or outcome-based) through servitization, demonstrated a great potential to radically reduce the environmental impacts of business, taking advantage of offering products "as-a-service". While moving from services that restore an asset's conditions towards providing support the customer's value chain processes that rely on that asset. In fact, providers of servitized business models (or product-service systems) take over an increasing share of risk from the customer. This also opens several opportunities for reducing the environmental impact, either incrementally or radically, and to set up truly circular business models.

How can these results be achieved? Different factors influence the **how** (through which mechanisms) and the **how much** (to what extent) of the environmental sustainability impact of servitization:

- **The type of business model** or product-service system offered, and the circular strategies enabled (Chapters 1, 2, and 3). Different classes of servitized business models enable different circular economy strategies, namely **reduce** (increasing resource efficiency), **reuse** of products at the end of the usage cycle, **remanufacture** of subsystems and components, and **recycle** to recover materials.
- **Product-oriented** is the more traditional business model, where, besides selling products, a company provides supplementary services such as repair, maintenance, training, and advice/optimisation or end-of-life management. It entails only incremental sustainability benefits, mainly related to operational optimisation, lifecycle extension, or enabling the proper collection and recycling of products.
- **Use-oriented** models, such as the typical "as-a-service" case, do not transfer the product ownership to the customer. Therefore, contractual relationships between providers and customers may incentivise the design of products for circularity, reduce operational costs, facilitate maintenance, intensify the use of materials, increase resource efficiency, and closing the loop. These drivers entail significant sustainability benefits.
- **Result-orientated business models** link the provider-customer relationship and the monetary flows to the achievement of specified outcomes or performance targets from asset usage. In these models, the provider takes over the responsibility for (most of) lifecycle costs. This will trigger great resource efficiency, lifecycle extension, and/or the product and business model design for multiple lifecycles. These mechanisms promise the most radical environmental gains.





- The environmental value drivers triggered (Chapter 4). They are the mechanisms that drive improved environmental performances of servitized business models, such as resource efficiency; lifetime extension; intensified product usage; improved recycling and reuse; product system substitution; dematerialisation and transparency; reduction of pollution and/or use of hazardous/toxic materials.
- The adoption of digital technologies (Chapter 5). Digital servitization is a key enabler of the smart circular economy. When devising sustainable servitized business models, companies should seize the opportunities offered by technologies (Internet of Things, Big Data and Analytics, Artificial Intelligence, 3D Printing, Blockchain, Augmented, and Virtual Reality) for both enabling advanced services and increasing sustainability in the different lifecycle phases of a product.

Previous research and notable cases have demonstrated the potential environmental gains (reduction of CO2 emissions, material wastage, or pollution) that can be achieved by applying the servitization logic in specific industrial sectors, and the current state of the art. Chapter 7 provides evidence about the machinery sector (slowly) moving towards equipment-as-a-service, the benefits attainable through lighting-as-a-service and cooling-as-a-service, and the household appliance reduction of waste and emission potential through revenue models such as pay-per-wash.

Is that enough to reach important sustainability gains? In order to translate theoretical sustainability benefits into actual achievements, the role of revenue models and pricing mechanisms should not be overlooked. They are the key to aligning the provider's and customer's value drivers with environmental drivers. Chapter 8 shows that often revenue and pricing methods are not aligned with the intended sustainability benefits. It suggests that value-based pricing mechanisms support the achievement of sustainability gains when transactional revenue models, typical of Product-oriented business models, are adopted. On the other hand, in Use- and Result-oriented offerings, new pay-per-emission revenue models and emission-based pricing mechanisms should be designed in combination with, for instance, pay-per-use models and value-based or cost-plus pricing. The definition of articulated revenue generation mechanisms that explicitly consider the environmental impact, allows gaining the greatest environmental benefits from servitization endeavours.

As illustrated in Chapter 6, servitization is also a lever for social innovation and social sustainability. Its potential descends from market inclusion, by facilitating access to product-service systems to a larger share of the population; job creation at a local level, thus fostering the well-being of communities; increasing resilience; and improving public health, as a result of greater environmental sustainability.

The Conclusion section sums up how to move forward in the servitization revolution for sustainability. While the role of institutions and political bodies remains critical in shaping regulatory and economic incentives towards a circular and sustainable economy enabled by servitization, companies are advised to put environmental sustainability at the core of their servitization strategy, rather than considering environmental benefits a mere "side effect" of their servitized offerings.

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01

Servitization and everything-as-a-service (XaaS)

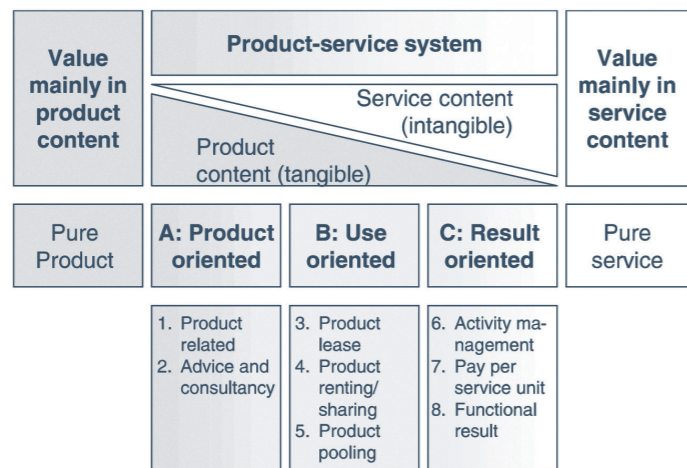


Figure 1 - PSS classification (Source²)

In the current global economy, companies are progressively transitioning from selling products to provide integrated solutions, offerings that incorporate goods and lifecycle services. This phenomenon has been conceptualized as **servitization**¹ or as the move to selling **product-service systems** (PSS)².

Servitization is defined as the innovation in an organization's capabilities and processes to create added value through a shift from selling products to selling an integrated combination of products and services³. It requires a strategic transformation of the company, that moves the value creation focus from the product or asset itself and its technical characteristics to its use in the customer's activities and value chain or its "value-in-use". Product Service Systems (PSS) can be classified into three categories based on the value propositions of their revenue models: Product-Oriented, Usage-Oriented, and Result-Oriented (Figure 1). Product-oriented PSS, are traditional and transactional, but the supplier besides selling products also provides supplementary services such as repair, maintenance, training, and advice. In Usage-Oriented PSSs, the supplier maintains ownership of the product and sells its accessibility, use, or purpose. In Outcome-oriented PSSs, the supplier essentially sells the specific results or outcomes that a product can achieve.

Servitization requires extending the service portfolio associated to products offered to customers. **Base services** refer to the basic needs of clients who are interested in purchasing the product, as well as any necessary spare parts. These services also include standard assurances of safety and compliance, such as guarantees. **Intermediate services** support customers with periodic maintenance, repair, and overhaul. **Advanced services** focus on achieving business outcomes and prioritise results. This categorization can be further detailed considering the varying degrees of activities that providers assume on behalf of clients. Figure 2 illustrates the 'services staircase'⁴. The staircase consists of eight steps, each symbolizing a distinct service offering provided by the supplier to the client. The y-axis represents the degree to which a service is oriented towards supporting a product (such as spare parts and repairs) or directly serving the client or its business outcomes. The horizontal axis indicates the supplier's assumed liability, which would have otherwise been the customer's burden. By assuming greater responsibility for risks, the provider has the potential to gain greater value. Companies that have a primary focus on supplying items and spare parts are positioned towards the bottom end of the scale. Companies that provide additional services, such as repair and maintenance programs, are classified at the intermediate level of the hierarchy. Companies that provide advanced outcome-based services are positioned at the higher levels of the hierarchy.

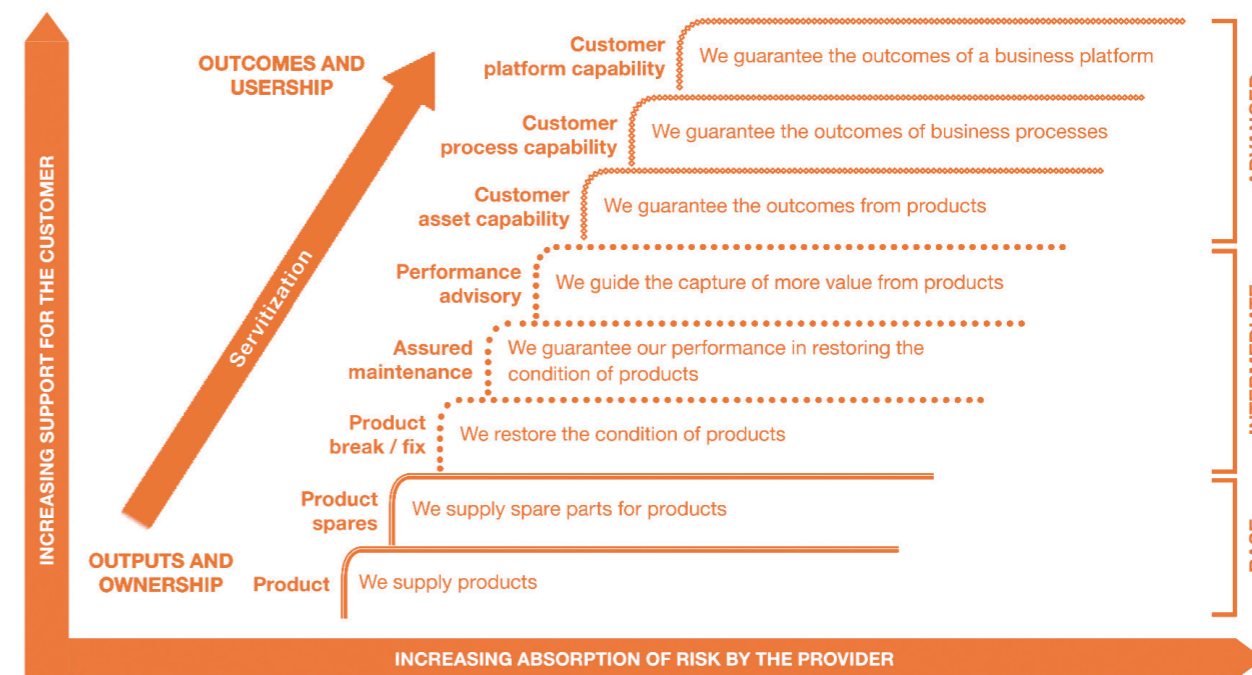


Figure 2 - Services staircase (Source⁴)

Servitized business models include the **Everything-as-a-service**, or **XaaS**, model. The notion of XaaS originated in 2007 within the field of information technology, where it referred to an IT delivery model that heavily relies on the virtualization of resources. This paradigm enables the provision of resources, such as infrastructures, applications, and data, in a flexible and immediate manner via the cloud. The term XaaS has been translated into several specific expressions, linked to the business it is being offered in, such as Heat-as-a-Service, Mobility-as-a-service, Washing-as-a-Service, Robot-as-a-Service.... Although there may be differences in these concepts, they all aim to define business models that rely heavily on digital technology and the cloud to offer products and services **on demand**⁵. One commonly used approach in manu-

facturing is the Equipment-as-a-service (EaaS). In this model, the manufacturer takes full responsibility for all activities necessary for the equipment to function properly and provides all the required services throughout the machinery lifespan⁶.

The notion of XaaS is strictly connected to mechanisms for generating revenues. There are two main categories of revenue models: the **subscription** mode, when a predetermined amount is paid at regular intervals, and the **"Pay-per-x"**. The latter allows for the collection of periodic income streams based on the customer's actual usage of the product (**Pay-per-use**), the machine's performance (**Pay-per-performance**), or the actual output produced (**Pay-per-outcome**) (Figure 3).

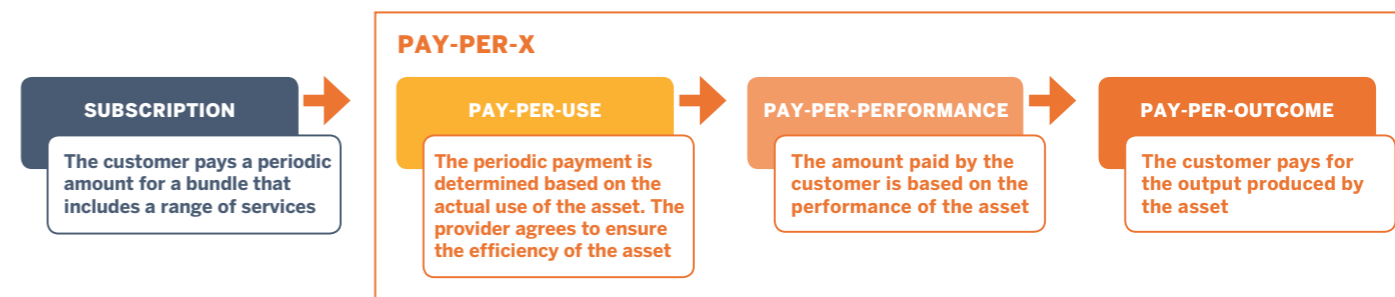


Figure 3 - XaaS Revenue model (Source: ASAP)

O2

Circular and sustainable business models

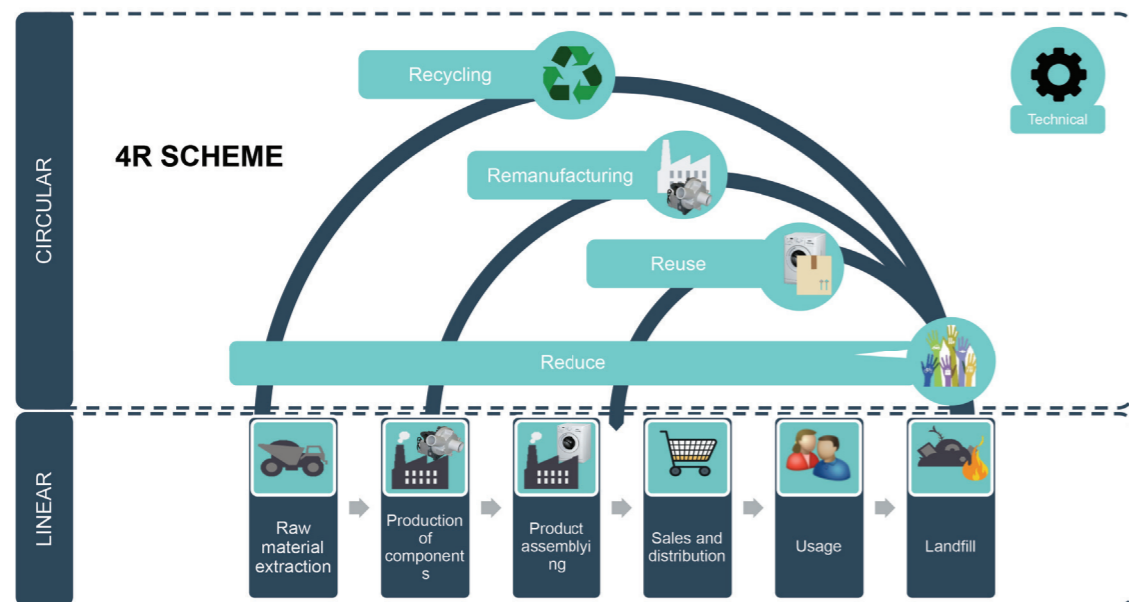


Figure 4 - The Circular Economy and the "4R" (Source: Laboratorio RISE, University of Brescia)

Manufacturing companies are at a strategic crossroads: they can either address environmental challenges within their corporate strategy and operations, accelerating the transition towards a more sustainable world, or remaining anchored to a linear paradigm of "take, make, waste". Maintaining a linear development model contributes to the process of rising global temperatures and climate change, with all its negative consequences, and exposes manufacturing companies to the ever-increasing risks associated with the scarcity of resources and critical raw materials.

The **Circular Economy** has been proposed as an answer to the call for **decoupling economic growth** from resource extraction, waste generation, and climate-change issues, since it promotes production and consumption systems in which products and materials are used multiple times and for multiple cycles⁷. Besides environmental concerns, the transition from a traditional, linear economy to a circular economy aimed at maximising the value of products, materials, and resources constitutes

an opportunity for firms to reduce costs, increase revenues, and achieve competitive advantage. In particular, it has been estimated that Circular Economy may increase the European gross domestic product as much as 11%, with savings on material costs up to €0.9 trillion.

Circular Economy can be defined as an **economic system restorative and regenerative by design**, implemented by one or more supply chain actors through one or more levers (circular product design, sustainable production processes, servitised business models, reverse logistics and enablers) in order to replace the end-of-life concept with **reducing**, alternatively **reusing**, **recycling** and **recovering** materials in production, distribution and consumption processes, for both technical and biological materials, with the aim to accomplish **sustainable development**⁸.

In particular, four main strategies (or "circles") can be adopted in the circular economy for technical materials, as depicted in Figure 4:

- **Reduce:** aims at increasing the efficiency of

use of material and energy resources, such as **energy efficiency** interventions or interventions to **extend the lifetime** of products through redesign, maintenance and repair services

- **Reuse:** aims at reusing finished products, through e.g. **reconditioning** and redistribution
- **Remanufacture:** the aim is to **recover and reuse components**, both for the production of new products and for reuse as spare parts. Replacement necessarily implies the disassembly of the finished product into its components
- **Recycle:** aims at recovering materials (plastics, metals, glass, etc.)

A hierarchy exists among the "R" strategies, according to the so-called Inertia Principle, proposing to "Do not remanufacture something that can be repaired; Do not recycle a product that can be remanufactured; Replace only the smallest possible part to maintain the existing economic value"⁹.

To gather the abovementioned benefits, companies need to implement **circular business models** that create, deliver, and capture value to improve resource efficiency **by extending the life** of products and components (e.g., through long-life design, repair, remanufacturing, and so forth) and

closing material loops. However, a transition to the circular economy implies several challenges, including economic and financial viability, market and competition, product characteristics, standards and regulation, technology, and user behavior obstacles.

In order to introduce circular business models, companies may invest on several levers (Figure 5). First, **products must be redesigned** to favor the use of secondary raw materials and the adoption of modular structures to foster repair and disassembly at the end of life. Second, it is necessary to **reconvert production processes**, minimising the generation of waste, scraps and leftovers, and of atmospheric emissions and pollution, using energy from renewable sources and encouraging industrial symbiosis mechanisms. Third, it is necessary to **rethink business models**, with the transition from traditional buying and selling logics to alternative **servitized models**, such as sharing, leasing and pay-per-use, capable of maximising the use and (above all) the re-use of products together with revenue generation. Lastly, it is necessary to **reconfigure supply chains**, implementing reverse logistics mechanisms for the recovery of end-of-life products and creating a true circular ecosystem with new forms of collaboration among supply chain players¹⁰.



Figure 5 - Circular transformation levers (Source: Laboratorio RISE, University of Brescia)



Mauro Frizziero
Service Strategy
Program Marketing Manager,
Socomec Group

The role of product design and service contracts for remanufacturing and lifecycle extension

Socomec is an electrical equipment engineering and manufacturing company, specializing in low-voltage energy solutions. In power conversion and availability systems, such as UPS (Uninterruptible Power Supplies) modular design is a key feature for us, and we are providing an industry new holistic design for platforming solution. The implementation of a **modular, plug-and-play architecture** using few standardized power electronic "bricks" is set to revolutionize the design effort, manufacturing process, maintenance operation, and the upgrade during the life for medium power Uninterruptible Power Supply (UPS) systems 10-200kW. This approach is not only transformative due to its scalable hardware construction but also because of the **intelligent embedded firmware functionalities that simplify operation and maintenance tasks**, thereby enhancing service performance & sustainability.

The market standard lifespan of this equipment class is 10-15 years with preventive maintenance. However, with our new modular brick solution, where all electronics are contained within the bricks and the remaining components are mechanical and electrotechnical with a lifespan over 30 years, our "Forever Young" **service contract** can extend the lifecycle to **over 20 years**. This results in more sustainable resource usage, a higher

ROI (return on investment) for customers and avoid the critical product replacement moment.

The replaced modules are **reconditioned**, as components within them have different aging curves and their wear depends on actual customer usage conditions such as load level, temperature, and grid quality. By analysing data collected during the product's life, our **repair centre** (built to support the new operational model) can selectively refurbish the modules, avoiding the disposal of components with still significant remaining life. These "as good as new" modules are reused for repairs via swap other units on the field in case of random failure events: the customer advantage is the immediate spare brick availability and therefore an extremely reduced MTTR (mean-time-to-repair) passing from legacy 2-3 hours to just a few minutes for onsite swap and offsite repair. We are currently exploring the possibility of creating a line of **second-hand products** based on these **second life modules** to be offered via an as-a-service model. In this perspective, customers would purchase a pure service, while we would keep full responsibility for ensuring the optimal performance of the product and its necessary maintenance. As a benefit this model would **combine cost efficiency with sustainability**, providing customers with reliable and high-performing UPS while minimizing environmental impact.

O3

Servitization and the circular economy



The introduction of servitized business models, where the use or the function of a product is sold instead of the product itself, is a great enabler of the circular economy paradigm. For instance, in the mobility sector, car sharing offerings where the providers do not sell cars, but offer turnkey solutions through a servitized scheme to satisfy mobility needs by private users are practical examples of how the sustainable and circular paradigm can be implemented. In general, different servitized business models types promise different potentials of circular value^{2:11} as illustrated in Table 1.

In traditional, **Product-focused business** models the product ownership is transferred to the customer, while the company can sell an additional portfolio of services, which are usually not customized. Base and intermediate services are especially offered to improve or restore the functionality of the product, such as maintenance

and repair. The (product) provider has no responsibility for product lifecycle and transactions are often single and independent from each other. However, extra services may be added: extended warranties, repair and maintenance contracts may be a source of value for the customer. The main revenue stream is represented by product sales, thus, these product-focused business models do not change the incentive for companies to maximize product sales, so they can only introduce incremental circularity and environmental sustainability improvements related to the fact that the sales of services may support the **lifecycle extension** of products.

In **Use-oriented business models**, customers do not own the product but pay a fee to gain access or use the product. The provider also takes over the responsibility for providing lifecycle services such as maintenance, repair and remote control. The provider has an incentive to design

products that can be re-used after a given time (e.g. a rental contract lasting five years). Also, the product should be easy to maintain when a maintenance contract is signed and should allow upgrading. Usage-focused business models are more promising than product-oriented ones in achieving circular benefits, since they **intensify the use of materials**, e.g. through sharing, increasing **resource efficiency**. If advanced maintenance or take-back agreements are signed, also the other circular value drivers (extend product lifespan and close the loop) can be achieved. However, sharing, leasing, pay-per-use could bring to a less careful usage by customers leading to a quicker wear and tear of products.

In **Result-oriented business models** the customer does not buy the product or system but pays a variable fee that depends on the achievement of a contractually set result in terms of performance

(e.g. availability) or outcome of its usage. Thus, the value is generated by an individualized and integrated combination of products and services to produce the expected results: the customer buys the performance, not the product and the related services. Thus, the provider is responsible for all lifecycle costs. This, in turn, provides a powerful incentive to design products for **resource efficiency, lifecycle extension** and circularity as a way to **minimize operating costs** (for instance, by reducing maintenance needs or increasing energy efficiency) and collecting back products to allow **multiple lifecycles**. Result-oriented product-service systems may be the most effective ones to move towards circular economy. However, it is generally difficult to measure outcomes and results in term of product/system performance and reach an agreement between customer and supplier to this regard.

Servitized BM Type	Circular mechanism		
	Increase Resource Efficiency	Extend Lifespan	Close the loop
Product-focused (customers have the product ownership).		+: After-sales services such as repair, extended warranties, maintenance contracts.	- Companies are incentivized to increase sales of new products.
Usage-focused (customers pay a fee to gain access to a product).	+: Product sharing among users.	+: Extra-Services such as extended warranties, predictive maintenance, repair +: Design-to-last +: Upgrade -: Quicker wear and tear due to less careful usage by customers.	+: Take-back agreement +: Design for closing the loop.
Result-oriented (customers pay a variable fee depending on the achievement of agreed results).	+: Product sharing among users.	+: Extra-Services such as extended warranties, predictive maintenance, repair +: Design-to-last +: Upgrade.	+: Take-back agreement +: Design for closing the loop.

Table 1 - Servitized business model types and their relations with Circular Economy: '+' means a positive effect of the BM type on the CE value driver, '-' means a negative effect (Source¹¹)



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A rental business model and lifecycle services for higher efficiency and lifecycle extension

Efficient logistics significantly impacts a company's overall performance, from reducing costs to improving customer satisfaction. Toyota Material Handling Italia offers a full range of forklifts, automation, complete warehouse solutions, and fleet management system. We provide also **equipment rental with full maintenance**. In recent times, by enhancing our rental offer with **fleet management optimization** and providing **blended fleets of new and refurbished equipment**, we have addressed key customer needs for flexibility, advanced financial tools and increased environmental sustainability.

Lifecycle based solutions are key to our After Sales offering, ranging from maintenance programs to full services tailored to application needs. Fleet management optimization and blended fleets are part of a broader strategy which aims to extract value by **reusing and recycling our assets** with a massive contribution to **zero emission** targets. This is made possible by **collecting data from customers operations** through telematics installed on our products and information collected by our capillary after sales organization.

Customer benefits include increased uptime (operational availability) as well as decreased running costs, while enabling budgeting accuracy.

We also aim at increasing the environmental sustainability of our service operations, by investing into technical competence, application knowhow and data analytics to **increase maintenance intervals** and **reduce repair trips** (thus reducing travel times, fuel consumption and lower the carbon footprint). Telematics and analytics are used on our technician's vans to increase travel efficiency and organize territory coverage. These results were achieved thanks to our strong focus on **personnel training**. Besides thoroughly redesigning our service processes, we have revised the internal training structure and processes. We adopted a hybrid model that integrates asynchronous methods, such as e-learning, with synchronous methods, such as virtual classrooms, culminating in "in-person" training during the final stage. This approach has significantly reduced travel across the national territory, optimizing learning methods and improving the speed of knowledge acquisition. All these improvements result in a higher service first-fix rate, reduced waste, and further limit the need for travel, thus minimizing the overall environmental impact of service delivery. Overall, it's a journey we have embraced to be a company that takes care in a responsible and sustainable way of the whole **product lifecycle**. This not only aligns with global **environmental goals** but also **adds significant value** to our customers.



Coen Jeukens
 VP Global Customer Transformation
 PTC ServiceMax

Product and service lifecycle integration for sustainability

If you design great products, you want to be able to sustain them once they are 'in the field'. Similarly, you want to use field data to design the next generation of products. PTC solutions connect both worlds of the engineering product lifecycle and after-sale service lifecycle. In doing so, OEMs can innovate faster, build more sustainable products, be more efficient with service delivery and drive more revenue from after-sales services.

At PTC we distinguish two aspects of sustainability. A **product-design component** and a **service-delivery component**. Accurate information on how products are being maintained and how they are being used, can improve product design. **Material use and footprint can reduce by 25%**. Energy consumption can go down by 15%.

Time-to-Market of new, more sustainable products can reduce by 33%. Having access to product design allows for more **efficient service delivery**. If product design is 'the plan', then all products in the field constitute 'the actual'. Comparing the two and managing your business on a management-by-exception basis, drives multiple benefits. First-time-Fix can go up by 30%, use of spare parts can go down by 25% and deployment of **remanufactured components can go up by 50%**.

The combination and integration of the worlds of engineering and service creates a reinforcing innovation, sustainability and efficiency loop. If your driver is sustainability, you get innovation and efficiency 'for free'.

O4

But... are servitized business models really sustainable?

The role of environmental value drivers



Environmental sustainability is the preservation of nature's services at an appropriate level, achieved by enhancing the integrity of the Earth's life-supporting systems. Circular Economy aims to design an economic system that prioritizes environmental sustainability. However, despite the potentials highlighted in the previous section, there is no inevitable connection between servitization and environmental sustainability: not all servitized offerings lead by definition to resource-efficient business models, and they can also result in burden shifting and rebound effects^{12;13}. As an example, a study analyzing the environmental impact of 27 actual cases of servitization showed that only in few cases they achieved radical environmental impact reductions, while more often they

entailed limited sustainability gains compared to expectations, and in few cases they even led to increased emissions¹⁴. In addition, servitization does not necessarily achieve the decoupling of economic growth from resource consumption¹⁵.

Why that apparent contradiction between potentials and reality? In addition to the abovementioned issues, **tensions arise between business and environmental sustainability objectives**. Usually, companies develop servitized businesses models **without a strong focus on sustainability**, prioritizing business objectives. Therefore, lower environmental impact stemming from servitized offering emerges almost as a "side effect", useful to provide additional marketing and sales arguments¹⁶.

Instead, sustainability objectives should be at the core of the development of servitized offerings. In fact, environmental gains occur when value creation, value delivery and value capture mechanisms are aligned with factors triggering environmental sustainability, such as resource consumption, lifecycle duration, or CO2 emissions. The concept of **environmental value drivers** allows uncovering the linkages between servitized business models and environmental sustainability. Environmental value drivers are mechanisms that drive improved environmental performances of product-service systems and servitized business

models¹⁷. The most common environmental value drivers are outlined in Figure 6.

Since these environmental drivers are not entirely independent, they have the potential to mutually reinforce each other, hence enhancing their positive sustainability impact. Conversely, they can also interact in negative ways that undermine the intended advantages^{18,19}. The characteristics of PSS stimulate different causation mechanisms that result in diverse effects on the environmental value drivers, leading to different sustainability impacts of PSS and servitized business models¹⁹.



Figure 6 - Environmental value drivers of servitized business models (Source:¹⁷)



Developing servitized solutions for industrial symbiosis

Alessandro Piubelli
 General Manager Business
 Unit Service & Aftersales,
 Turboden

Turboden is a global leader in the design, manufacture and maintenance of Organic Rankine Cycle (ORC) systems, that generate electric and thermal power exploiting multiple sources, such as renewables (biomass, geothermal energy, solar energy), traditional fuels and waste heat from industrial processes, waste incinerators, engines or gas turbines. Turboden developed a special inline separator to **remove lube oils** and other pollutants from the organic fluid of its ORC Power plants. The separator can be connected to all the existing fleet in operation and removes, day by day, the pollutants that are collected in a tank. This system can be **sold or rented, as extension of a service contract**, until the separation process is completed. The separator can be used in the biomass or waste heat recovery sector.

The organic fluid can be cleaned and renewed by the separator for years with the power plant in operation avoiding the necessity for a total fluid change (>5 tons) with disposal. The system contributes to keep the highest possible performances, without downtime, reducing the potential pollutants of 97% and the opex costs for the customer.

O5

Digital technologies for the servitized smart circular economy

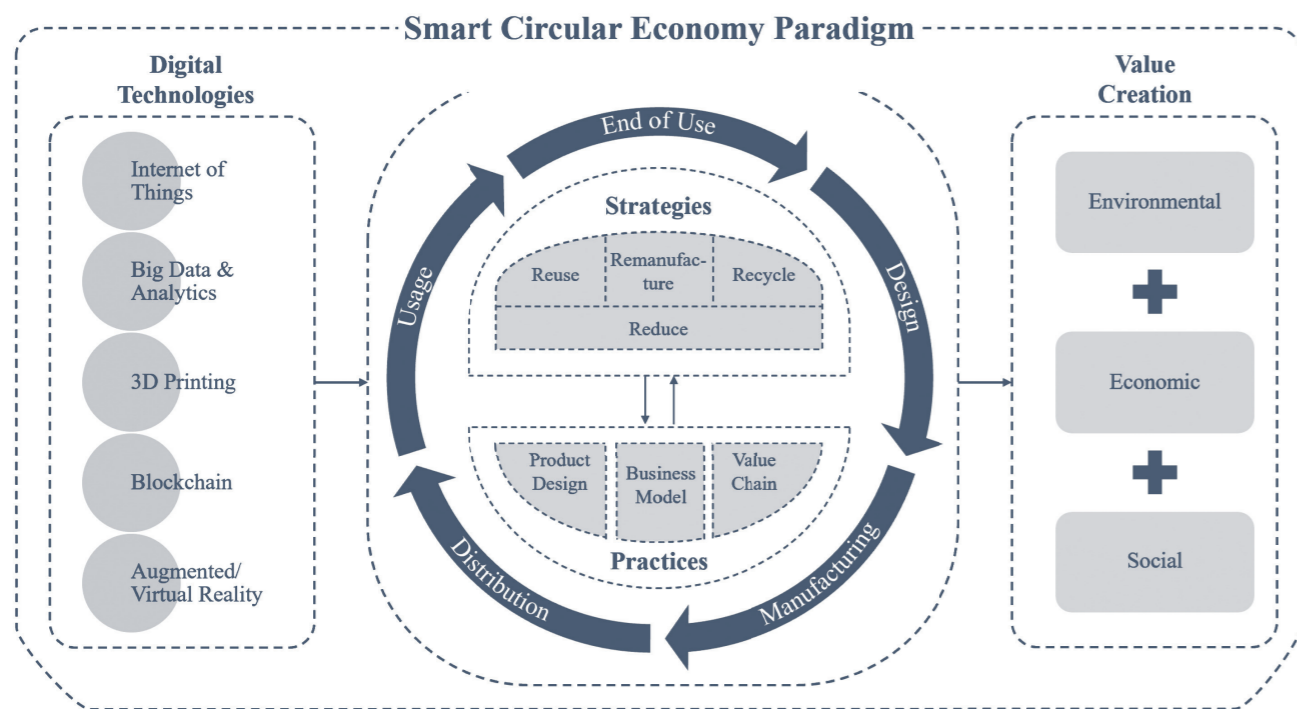


Figure 7 - The smart circular economy paradigm (Source:²⁰)

Digital technologies are a powerful support for the development of sustainable servitized business models. Through digitalization, the data collection, data integration, analysis and data automation functions can be activated to enable sustainable practices together with the deployment of the servitized business models (e.g. measuring the amount of usage to bill in pay-per-use contracts).

Internet of Things, for example, enables real-time remote monitoring of product usage, status, and location and companies have the opportunity to build knowledge on how customers are using products and

how to better service them. Moreover, when products become smart, product upgradability is facilitated, since providers may upgrade digital components, contrasting premature or planned obsolescence and the entailed material waste.

Digital Servitization, thus, is crucial within the Smart Circular economy paradigm illustrated in Figure 7, "an industrial system that uses digital technologies along the product lifecycle to deploy servitized and circular strategies and practices, aiming at value creation through an increased environmental, social, and economic performance"²⁰.

The framework in Figure 7 suggests that digitalization, fueled by the application of a diverse range of digital technologies, enables a systemic redesign of products, business models (**servitization**), and value chains, impacting all the lifecycle phases, to reduce material and energy consumption, reuse products, remanufacture components, and recycle materials. This, in turn, promotes value creation and the achievement of enhanced sustainability performance on the triple bottom line. The underlying principle is that physical flows should be progressively replaced by information flows, as making a better use of data would reduce the use (and transportation) of materials. Table 2 summarizes

the sustainability impact of digital technologies when adopted in servitization, on the lifecycle phases of a product, from design to the end of use.

It follows that digital technologies are not an end in themselves: digitalization alone will not automatically lead to value creation for the customers, better performance and a lower environmental impact. When backed by a clear strategy and design of the (servitized) circular economy outcome, they will have a critical role in the redesign of products, business models, and supply chains.

Digital Technology	Product Life-cycle Phase				
	Design	Manufacturing	Distribution	Usage	End of Use
Internet of Things		Monitoring of data to achieve operational excellence by reducing scraps and equipment wear and tear.		Enabling the provision of circular product-as-a-service business models (pay per use, sharing).	Tracking products to increase collection rate.
Big Data and Analytics, Artificial Intelligence	Transforming product-in-use data into valuable information to improve product design for circularity.			Enabling the provision of preventive and predictive maintenance.	Informing better decision making for reuse, remanufacturing, and recycling.
3D Printing	Increasing the use of recycled materials (recycled plastic polymers or metal powders). Increasing product personalization to avoid the early disposal of products.	Minimizing material losses, scraps, and waste (additive, not subtractive process). Reducing the need to hold large inventories.	Reducing the need for transportation.	Enabling the local and on-demand production of spare parts for repair and upgrades.	
Blockchain		Ensuring trust, transparency, traceability, security, and reliability in the value chain to drive green consumer choices and prevent greenwashing.		Allowing automated transactions (e.g., smart contracts), leading to greater efficiency.	Financial incentivization to drive users' behavior towards increased recycling.
Augmented and Virtual Reality	Facilitating the redesign of products to improve circularity.			Providing remote assistance and guidance for maintenance activities.	

Table 2 - The role of digital technologies for enabling a smart, servitized circular economy (Adapted from²⁰)



Stefano Butti
CEO, Servitly

Digital Product Service (DPS) data for sustainable servitization

Servitly is a Cloud-based, configurable IoT application that helps OEMs and service providers harness data from connected products to streamline and enrich their after-sales services and processes. Through Servitly services also become "connected". This allows organizations to reduce costs and risks of their after-sales operations, enrich their offerings with IoT-enabled solutions, establish long-lasting relationships with customers, generate new recurring revenue streams from subscriptions, spare parts and consumables and new service models, like Equipment-as-a-Service. The most distinguishing feature of Servitly is the Console, a no-code environment for configuring all organization-specific application details, that supports OEMs enjoy the freedom and autonomy to set unique solutions and accelerate their time to market through a "buy and configure" approach.

Data from connected products provide OEMs, service providers, and customers with deeper insights into product performance, energy consumption and environmental impact. OEM-provided digital services,

such as Performance Advisory and Aided Maintenance, help customers comply with usage and maintenance best practices, improving product health, while data-driven after-sales activities like maintenance, repair, and refurbishment further extend its life cycle.

One further possibility for OEMs is offering a pay-per-use model that shifts the risks associated with ownership and the responsibility for maintaining the product from the customer to the OEM. This encourages OEMs to innovate, improve efficiency, optimize equipment utilization and promote component reuse, which benefits both customers and the environment.

Finally, data is also valuable in remanufacturing practices, helping OEMs evaluate the risks associated with reintroducing products and components to the market by providing an objective and up-to-date assessment of the condition and health of products.

O6

The social dimension of servitization: towards a better future

Novel revenue models such as pay-per-outcome can alleviate resource shortages and improve access to goods globally. Therefore, they also provide solutions to address societal issues like elderly isolation and poverty. In the following, it is illustrated why Servitization is a form of social innovation and could therefore be a key transformation to address also major social challenges, besides environmental ones (based on²¹).

Social innovation refers to innovations that address critical societal challenges, such as poverty, inequality, and environmental degradation. Servitization is indeed a multi-level transformation. This move can bring significant changes on companies (**micro** level), on entire industries (**meso** level),

as well as on the broader economic system and society (**macro** level). At micro level, servitization changes the business practices, and forces the shift from short (e.g. one-shot/transactional selling of goods) to long-term orientation with the customers (e.g. multi-year contractual services, partnership agreements, outcome-based contracts). It also fosters new skills and a shift in leadership and company's culture. At the meso level, servitization redefines ecosystems, promotes collaboration and co-creation across individuals and firms. Finally, at the macro level, servitization encourages people to adopt more responsible and sustainable behaviours. Therefore, in the long run, it can change the social practices of even large communities. Figure 8 illustrates the six key social benefits of servitization.



Servitization is thus strongly connected with social innovation, and recent studies demonstrate how the move to a service business in the manufacturing sector could drive significant social and environmental benefits. In particular, both social and environmental benefits are most impactful when the needs of custom-

ers, communities and environment are considered from the **early design stages** of product-service solutions. This is a fresh perspective for managers and policymakers, that highlights the potential of servitization in addressing modern societal challenges and contribute to social progress.

Market equity, inclusion, and democratization

- Servitization provides broader access to services, particularly for marginalized and low-income groups, through models like pay-per-use

Job creation and worker satisfaction

- The service-based economy creates more labour-intensive jobs, increasing satisfaction and productivity

Improvement of local communities

- Servitization fosters local economic development, especially in regions where digital service centres are established

Public health enhancement

- The adoption of sustainable production models reduces environmental impact, improving public health

Customer satisfaction

- Customized service solutions lead to higher customer satisfaction compared to product-centric models

Increased resilience and competitiveness of industrial firms

- Servitization, especially when supported by digital technologies, strengthens industrial supply chains, making them more resilient to global crises

Figure 8 - Six social benefits of servitization (Adapted from²¹)

07

The potential of servitization and “as-a-service” business models in selected industries

Towards “Equipment-as-a-service” in the machinery industry



In the machinery and production equipment sectors, services traditionally have been considered a necessary evil. Therefore, it is not surprising that even today advanced services are provided only by a minority of manufacturers, while on the contrary the industry maintains a strong **product-centric orientation**, also as a legacy of the small size of most companies in the industry. According to an ASAP study on machinery companies in Italy, the sales of equipment is the predominant part of the turnover, making on average 75%: the “after-sales” component, generates the remaining quarter of turnover, but mainly made through the sales of spare

parts²² (see Figure 9). Despite their transformative potential and the promise of servitization, ‘as a service’ sales models are still rare, with **only 18% of companies** currently offering them, but with a little impact on their turnover. However, more than half of the Italian machinery manufacturers surveyed are implementing a targeted strategy to develop their service business and expect a significant increase in service revenues in the future. In this context, new digital technologies and higher levels of automation are making these opportunities more relevant for the machinery sector.

Meanwhile, as their products and services evolve, more machinery

and equipment companies will wield sustainability as a commercial differentiator. Leading machinery companies create value by combining equipment sales and service contracts with **circular models** designed to upgrade the machine, reuse the equipment, their key parts or recover valuable materials. Environmental sustainability has an increasingly important role: manufacturers are pushed by customers, shareholders, and institutions to develop more sustainable equipment, trace raw material origins, reduce energy consumption and make their manufacturing processes transparent.

New servitized business models represent an answer to these demands. In such models, referred to as **Equipment-as-a-service (EaaS)**, the manufacturer is responsible for the proper functioning of the equipment and performs, therefore, all required services over the **product lifecycle** (e.g. taking care of spare parts, consumables, recalibration of settings, preventive maintenance...). EaaS entails an incentive to adopt levers that are typical of the circular economy paradigm, such as **long-lasting and circular design**, use phase intensification, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling. By shifting ownership, control,

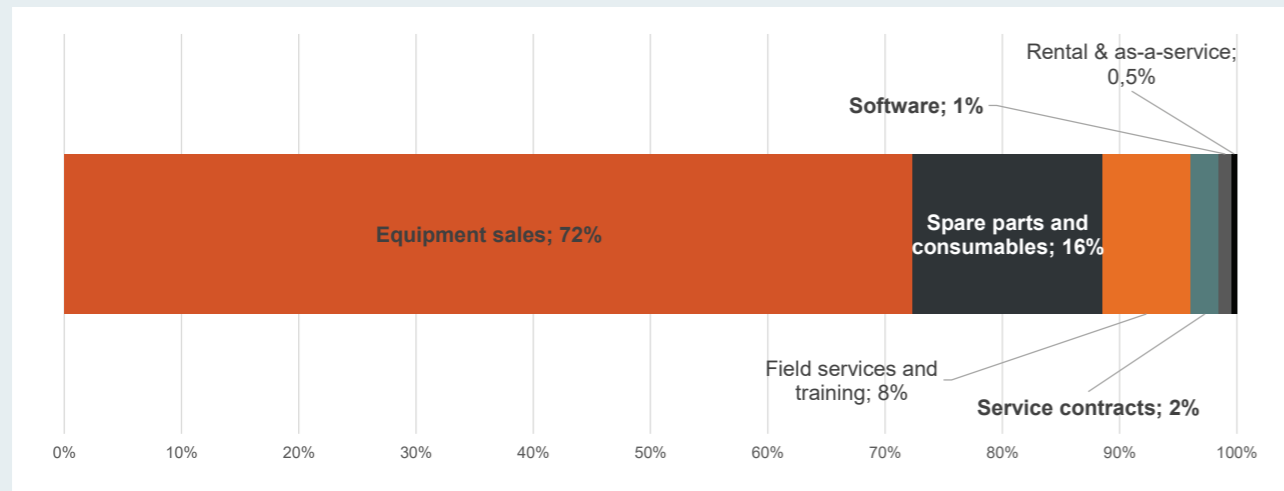


Figure 9 - Turnover composition of a sample of 160 machinery manufacturers surveyed by ASAP and Digital Industries World Italia (Source²²)

and responsibility to the providers, EaaS models help to maximize resource productivity and lifetime value, using less material, and decreasing waste and operational cost. At the end of the utilization cycle, retained ownership also enables the remanufacturing and recycling of valuable materials.

Moreover, since the carbon footprint of a typical machine in the utilization phase often exceeds that of its construction phase by a factor of 20, by leveraging the investments and capabilities of Industry 4.0, EaaS models have the potential to considerably reduce the

environmental impact. A previous study conducted by SYSTEMIQ showed that CO2 emissions can be reduced by approximately 37% when the machine is offered in a result-oriented pay-per-use model²³. Additionally, attaching to EaaS a demand pooling market production platform, emissions can be reduced up to 65%. The decarbonization potential stems mainly from resource efficiency in the utilization phase: optimization of efficiency and energy consumption by design, increased production capacity and utilization, combined with lower scrap and byproducts. Moreover, according to the same study, the Total Cost of

Ownership can be reduced up to 24%, depending on the EaaS scenario. This shows how EaaS business model can entail both environmental and economic benefits for the customer.

Servitization therefore is perceived as a means to achieve sustainability by machinery companies. (see Figure 10)²⁴. However, as of today both the offering of services directly and explicitly related to environmental sustainability and of EaaS business models are still at an early stage of development.

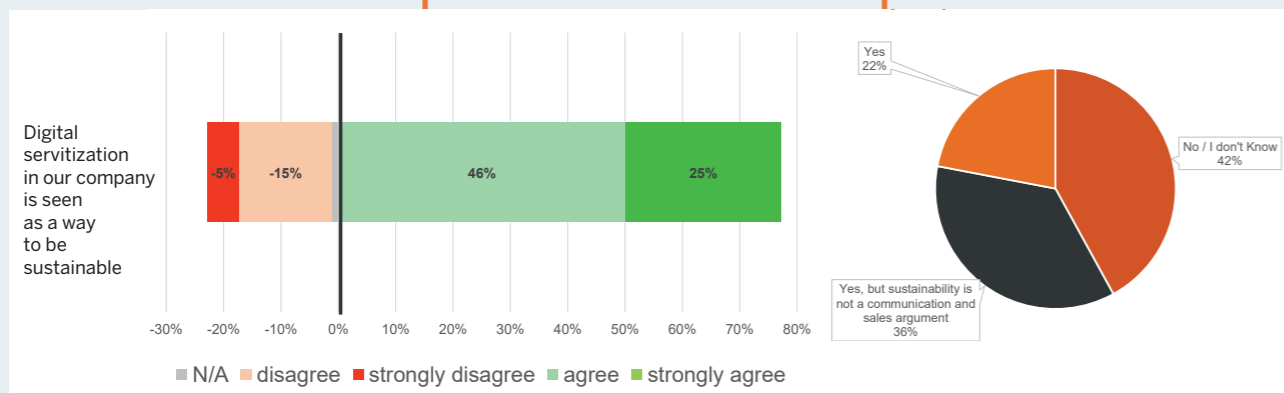


Figure 10
On the left: the role of Digital Servitization to increase manufacturers sustainability according to a sample of 314 companies worldwide (Source²⁵)
On the right: diffusion of service offering directly related with sustainability in a sample of 160 machinery companies (Source²²)



Marco Trullo
Head of Service + Success Italy
GF Machining Solutions

Developing end-of-life services for customer satisfaction and environmental sustainability

GF Machining Solutions sells and services high performance EDM, Milling and Laser machine tools in die & mold and part productions fields of application. To enhance our service offerings and meet increasing customer demands for sustainability, we have introduced two key services: Machine Recycling and Rotary Table Repair. These services are designed to extend the lifecycle of machines and their components while reducing waste and overall environmental impact. Since 2022, VAMCONTROL, a specialized company within the GF Machining Solutions group, has been pivotal in executing these services, further reinforcing our commitment to sustainability.

The Machine Recycling service is a sustainable solution for disposing of obsolete machines, offered to European customers. Through a structured process, machines are dismantled, and reusable components such as electrical cables, metal sheets, and electronic boards are salvaged. Depending on the condition of the machine, a buy-back value is offered, providing customers with an easy, responsible option to clear old equipment from their facilities.

The Rotary Table Repair service allows us to identify and replace only the damaged parts of a rotary table instead of a full refurbishment. This selective approach significantly reduces repair costs and material waste, while maintaining the high quality of intervention. Customers have the flexibility to choose between a complete replacement (faster but more expensive) or a part-specific repair (cheaper but with longer lead time). This choice optimizes the lifecycle of components that are still functional, promoting both economic and environmental sustainability by avoiding unnecessary replacements.

Through GF Machining Solutions' leadership in sustainability initiatives and VAMCONTROL's operational expertise, we give new life to parts that might otherwise go to waste. We offer customers affordable, pre-certified components that maintain the same level of reliability as new ones, and we ensure that high-value components, such as spindles and tables, undergo rigorous quality checks before being reintroduced into the market. This approach not only minimizes environmental impact but also supports customers in achieving cost-effective, eco-friendly solutions.

Lighting-as-a-Service

Lighting currently accounts for a staggering 14% of electricity use worldwide²⁶. The impact of a lighting system occurs largely during use; hence a particular focus should be put on limiting the impact during lighting systems' useful life through optimized usage, lower energy consumption and to lengthen the time of use by increasing longevity, reparability, and upgradeability. **Lighting-as-a-service (LaaS)** offers an alternative based on the use rather than ownership of the lighting system. Users pay for the light provided rather than for the lighting equipment itself. This method is based on service contracts in which the lighting provider installs, maintains, and take care of the end-of-life of the lighting products, for a contractually agreed number of years. The result a move from a transactional approach to a contractual partnership with a **performance commitment**, entailing an increased efficiency and durability of the lighting system. In practice, the consumer buys a light level (in lux), a level of availability, and a guarantee on energy consumption. This long-term agreement which requires an **ecosystem** of financial partners, installers, maintenance actors, and recyclers.

From a technological point of view LaaS facilitate the adoption of **up-to-date, efficient technologies**. The deployment of LED lightings leads to cost savings and environmental benefits with respect to conventional lighting during the lifecycle, reducing by 50% to 90% the energy consumption. In addition, LED fittings may have an operational lifetime of up to 20 years, reducing material use in production. The integration of motion sensors and **IoT technologies** enhances the regulation of light usage through **lighting management systems**, therefore mitigating potential energy wastage. Moreover, LED technology paired with the Internet of Things, offers **traceability**. Intelligent systems constantly monitor the lighting products and enable preventive maintenance.

According to²⁷, LaaS thus offers economic, environmental, and operational advantages, harmonizing performance and sustainability goals. The Light-as-a-Service solution typically includes the design, financing, installation, and maintenance of lighting under a single contract. Upon the termination of a LaaS contract, the provider takes over the responsibility of reclaiming the value of the equipment, primarily through reuse, or recycling. Through financing services, LaaS enables customers the renovate lighting without the need for any initial investment, resulting in prompt reductions in operational expenses. Moreover, the provider takes over the responsibility of both maintaining and updating the systems, thus ensuring their optimal performance and availability.

Implementing a LaaS business model necessitates a transformation in the provider's organizational and cultural practices to generate value for its customers and manage interactions with other stakeholders within the ecosystem. Conversely, from the **customers' perspective**, outsourcing lighting results in a reliance on the operational efficiency and dependability of the service provider. Any malfunction or disruption of service can immediately impact their operations. In the event



of an unexpected breakdown, the service provider may not respond promptly and fail to meet contractual obligations.

Example - In around 2012, Philips Lighting (now Signify), in partnership with the Ellen MacArthur Foundation and Dutch architect Thomas Rau, initiated trials of the Light-as-a-Service (LaaS) or pay-per-lux concept. This concept has then undergone subsequent development and expansion in different settings, including circular lighting. The company provides expert evaluation and strategic planning services to identify the optimal lighting solution for the client's requirements, full implementation of new energy-efficient lighting systems, and elimination of outdated a lighting product, together with continuous maintenance and support services. In addition, it offers periodic upgrades and replacements of fittings and lighting components to guarantee that the system remains current with the most recent technology and energy efficiency criteria.

Cooling-as-a-Service



Cooling is essential for industrial production, for example to preserve food and medicines, as well as for residential needs in several regions of the world. According to²⁸ the demand for refrigeration is increasing dramatically: the energy required for chilling alone is expected to triple by 2050²⁹. Cooling consumption places a heavy burden on energy resources and the production of cooling technology has significant sustainability impacts. In fact, it is causing an increase in energy consumption and the use of ozone-sensitive refrigerants (fluorinated gases) that have one of the highest global warming potentials. There is therefore an urgent need to reduce energy intensity and pollution from cooling while ensuring the accessibility of efficient cooling systems. At the **political level**, international multilateral agreements (Paris Agreement, Kigali Amendment to the Montreal Protocol, United Nations Urban Agenda) are moving in this direction, and national regulations address other sustainability shortcomings in the production of cooling equipment, including the prohibition of premature and planned obsolescence of cooling equipment, incentives for remanufacturing, and the management of WEEE. At the **business level**, to move towards

a fair and circular economy for cooling, it is necessary to change the economic model of production and consumption. The servitization business model can help overcome barriers, align incentives, and unlock investment in cleaner technologies.

In Cooling-as-a-Service (CaaS) users pay for a certain amount of cooling provided by a service provider instead of buying the cooling equipment themselves. The CaaS business model enhances the availability of ecologically sustainable cooling. It entails users paying for the cooling they receive based on the desired outcome, such as maintaining a specific temperature, or the amount of cold air produced, rather than the physical product or infrastructure used to supply the cooling. A technology provider is responsible for the installation and maintenance of the cooling equipment. The costs are recovered by the provider through regular payments made by the customer. The payments for these services can be calculated based on the usage of the service, such as euros per ton of refrigeration or euros per kilo of food held in a cold room, or they can be fixed at regular intervals. The payments are predetermined based on actual usage, rather than being influenced by savings as seen in shared savings energy performance contracts. This enhances the client's ability to anticipate costs and visualize cost reductions, which is a significant advantage in highly unstable and dynamic markets. Such business models leverage embedded sensors and the Internet of Things to provide remote monitoring and enhancement of cooling appliance performance and efficiency.

Cooling as a Service (CaaS) offers cost-effective access to cooling solutions, facilitates the reduction of material and resource use, and encourages the adoption of energy-efficient technology. Customers gain from CaaS models because of **reduced energy and maintenance expenses**, the absence of initial capital investment, access to top-of-the-line equipment, and a clear and **predictable pricing system**.

CaaS also mitigates the perceived technology risk for customers, as they are not obligated to make direct investments in technology. By adopting CaaS, technology suppliers are motivated to enhance their profitability by carefully choosing the most effective technology, optimizing operating efficiency, and ensuring correct maintenance of cooling systems. Also, they are incentivized to provide cooling solutions that can be used for an extended period, for example, by employing modular designs that allow for easy reusability, replacement, and recycling of components. Research has suggested that CaaS business models have the potential to **reduce customer expenses by up to 23% and save 49% of carbon emissions** by optimizing electricity usage and minimizing refrigerant losses³⁰. Moreover, effective maintenance practices can lead to a significant decrease in electricity consumption, with potential savings of up to 20%²⁹.

The CaaS business model encounters similar obstacles as other servitization models, including organizational and cultural transformations, risk reduction, increasing client knowledge of CaaS, establishing suitable monitoring, documentation, and pricing protocols, and offering technical support. Furthermore, the financial advantages of energy-efficient equipment are usually realized over a long period. Nevertheless, notable instances of the model's implementation can be observed.

Examples - ColdHubs adopted the CaaS model in solar off-grid refrigeration in Nigeria's agriculture industry, resulting in a 50% decrease in food waste, increased earnings, and a reduction of 460 tonnes of CO2 emissions per year. This was achieved by eliminating the usage of diesel generators and harmful refrigerants commonly utilized in the region. Kaer implemented a Cooling-as-a-Service solution in an Indian real estate complex, utilizing a chiller plant powered by artificial intelligence, which operates with high efficiency and runs entirely on solar energy²⁸.

Servitization for sustainability in household appliances: a “pay-per-wash” approach to the washing machines industry

With a market sales of around 15 million units per year in Europe and an installed base close to 200 million units, washing machines are the most diffused among large home appliances in Europe. They are characterized by medium-long lifespan (10-11 years) and consume resources (water, electricity, and detergents): during their use: they are the most resource-intensive domestic appliance consuming 1.4 Mt of materials, 24.2 TWh of electricity, and 1.5 billion liters of water in Europe per year²³. The actual lifespan depends on the usage intensity: an entry-level washing machine has a useful life of about 2,000 washing cycles, while a premium one can achieve up to 8-10,000. Although washing machines are standard products, they may vary widely in weight and

composition: a machine weights between 70 and 100 kg and contains on average more than 20 different materials, including steel, grey cast iron or concrete, carboran plastics, mineral filler, aluminum, EPDM polymers, chipboard, ABS plastics, glass, and polypropylene. Start-ups and experimentations by large companies have demonstrated the feasibility of subscription and pay-per-use revenue models and how digital technologies (especially IoT and data analytics) and purposeful product redesign enable them. How the adoption of digitally servitized business models can translate into environmental sustainability gains? Compared to the current linear scenario, taken as a baseline, a “pay-per-wash” digital servitization business model has been

modeled through a what-if simulation model, described in³¹ and illustrated in Figure 11. The model allows describing how the circular economy levers are applied at the product, usage habits, and supply chain levels (configuration drivers), and how they translate into characterization mechanisms that trigger environmental value drivers (usage intensity and its environmental effects, and stocks and flows and their effect on the washing machine installed base and resource extraction). The impact block measures the sustainability impacts at the environmental, economic (user and supply chain), and social levels.

The digital servitization circular scenario is based on a pay-per-wash revenue model that includes

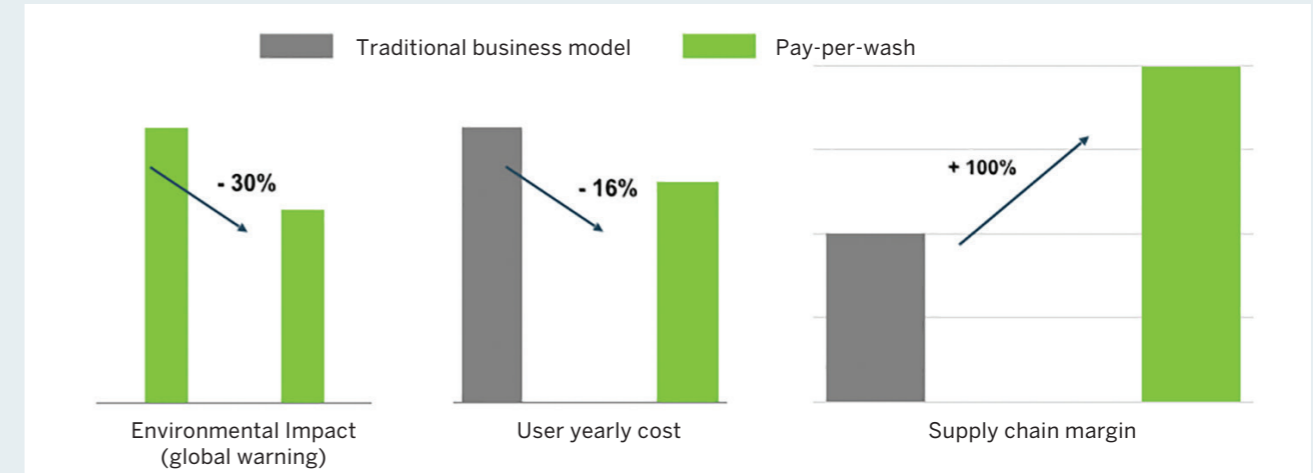


Figure 12 - The environmental sustainability and economic potential of moving to a “pay-per-wash” washing machine business model (Source³¹)

Configuration driver		Characterization		Impact	
D1. Product 	Product Capacity; Energy Efficiency Class; Lifespan; Material composition; Usage specific consumption	C1. Usage 	Number of usage cycles; Energy, water, and detergent consumption	I1. Environmental 	Global Warming Potential (Raw materials extraction, Manufacturing, Distribution, Maintenance & Repair, Refurbishment, Recycling, Landfilling)
D2. User 	Household Size; Usage condition; Frequency of utilization; Business Model choice			I2. Economic for the user 	Total cost per user (purchasing price, renting fees, usage consumables)
D3. Supply Chain 	Refurbishment and recycling rates; Specific impacts and costs for Supply Chain activities; Sale price and renting fees; Man working times	C2. Stock and Flows 	Product stock; Product life; Product in-flows; Product refurbished flows; Product recycled flows; Product landfilled flows	I3. Economic for the Supply Chain 	Supply Chain profit; Total Supply Chain revenues; Total Supply Chain costs
				I4. Social 	Full Time Equivalent job creation

Figure 11 - The reference model for analyzing the sustainability impact of washing machine servitized business models (Source³¹)

the cost of a maintenance contract for a number of years and lifecycle service, while the product is billed according to the number of washing cycles carried out by the user. Such “as-a-service” business model is enabled by circular product design, product digitalization, and the setting up of reverse logistics flows that allow for multiple usage cycles. Washing machines are equipped with IoT technology that supports the provision of personal advice on how to save energy and reduce costs during washing operations. Smart washing machines allow to increase in the loading rate up to 95%. With an average first usage cycle of 2,000 cycles during the first contract, reuse and recycling strategies can successfully be implemented with the new business model, leading to a reconditioning rate of up to 30%, with a possibility of a second refurbishment on a small percentage of cases, and high recycling rates. Also, such a scenario will decrease the number of new washing machines manufactured by around 50% because of the lifetime extension achieved through the combination of WM design, maintenance, and repair

services included in the pay-per-use business model and the reduced usage achieved through pay-per-use.

The impact at the environmental and economic levels is depicted in Figure 12. These effects at the characterization level lead to a reduction of 30% in the environmental impact measured in terms of CO₂e emitted. This result is mainly obtained thanks to the reduction of the environmental impacts connected to the usage phase, due to the combined effect of the reduction in the energy, water, and detergent consumption of each single washing cycle, generated from the adoption of high-efficient washing machines, of the overall reduction in the number of washing cycles due to the increase in the capacity and loading rate. Given the reduction of flows, distribution impacts are lower too. This environmental impact reduction offsets the higher specific environmental impacts connected to the production and reconditioning of high-efficient washing machines.

On the economic side, a reduction of the yearly user cost of 16% is observed, thanks to

increased washing efficiency and digitalization and the adoption of the “pay-per-wash” business models. On the other hand, the supply chain margin can significantly increase, as a result of increased operational efficiency and higher revenues, thanks to pay-per-use fees that include also maintenance and repair services, that counterbalance the higher costs related to premium appliance production and lifecycle services.

This household appliance example also shows the role of systemic ex-ante assessment of the results achievable through the adoption of servitized business models, by developing ad-hoc simulation tools. Companies, institutions, and policymakers should carefully assess the sustainability impacts of circular economic scenarios in a systemic way, either at the micro or at the macro levels. By combining digital servitization with actions at the product design and reverse logistics level, benefits on the triple bottom line can be achieved in the long run at the micro and macro levels.

08

The future of servitization for sustainability: aligning revenue models and pricing with environmental value drivers

SERVITIZED BUSINESS MODEL (PSS)	Product-oriented		Use-oriented		Result-oriented		
REVENUE MODEL	Traditional (one off transaction + service fee)	Fixed fee / pay-per-period	Pay-per-use	Hybrid (combined)	Pay-per-performance (availability, emissions)	Pay-per-outcome	
PRICING MECHANISM	Cost-plus		Market-based	Value-based	Emission-based		
ENVIRONMENTAL VALUE DRIVER	Resource efficiency (usage)	Lifetime extension	Intensified product usage	Increased/Improved recycling and reuse	Product system substitution	Dematerialization and transparency	Reduction of pollution and/or use of hazardous/toxic materials

Figure 13 - A framework to guide the alignment among the revenue and pricing methods of servitized business models and environmental value drivers (Source¹⁷)

How to achieve the full sustainability potential of servitized business models? Reflecting on the selected cases discussed in the previous chapter in the light of the conceptual elements, we understand that the more the servitized business model adopts a use- or a result-oriented approach, the higher the sustainability potential. Also, the richer the offer of lifecycle advanced services, the greater the value for the customer of the solution offered and thus the business potential.

But to make such sustainability potential a reality, the design and the deployment (at both the provider's and customer's sides) of the servitized business model should trigger one or more of the environmental value drivers described in Chapter 4. To effectively enable this match, the role of revenue models and pricing strategies is crucial. Manufacturers and service providers need to align their revenue models with the new value they provide, adopting also innovative pricing structures

that reflect the unique characteristics and benefits of the new offerings. Revenue models and pricing mechanisms contribute to shaping incentives and behaviors toward sustainability outcomes, as they can translate either into **empowerment or adverse mechanisms**¹⁹.

To guide such alignment, a framework (developed by¹⁷, is proposed in Figure 13. It identifies four key features for the alignment of PSS offerings and environmental sustainability and presents their configuration options. Two new options are suggested in the framework: a **pay-per-emission** revenue model (as a subcategory of pay-per-performance) and an **emission-based** pricing mechanism, modelled on a carbon pricing logic.

However, typical patterns of servitized offerings may not be aligned to realize the sustainability potential. Let's take the case of the more traditional **Product-oriented PSS business model**. We know

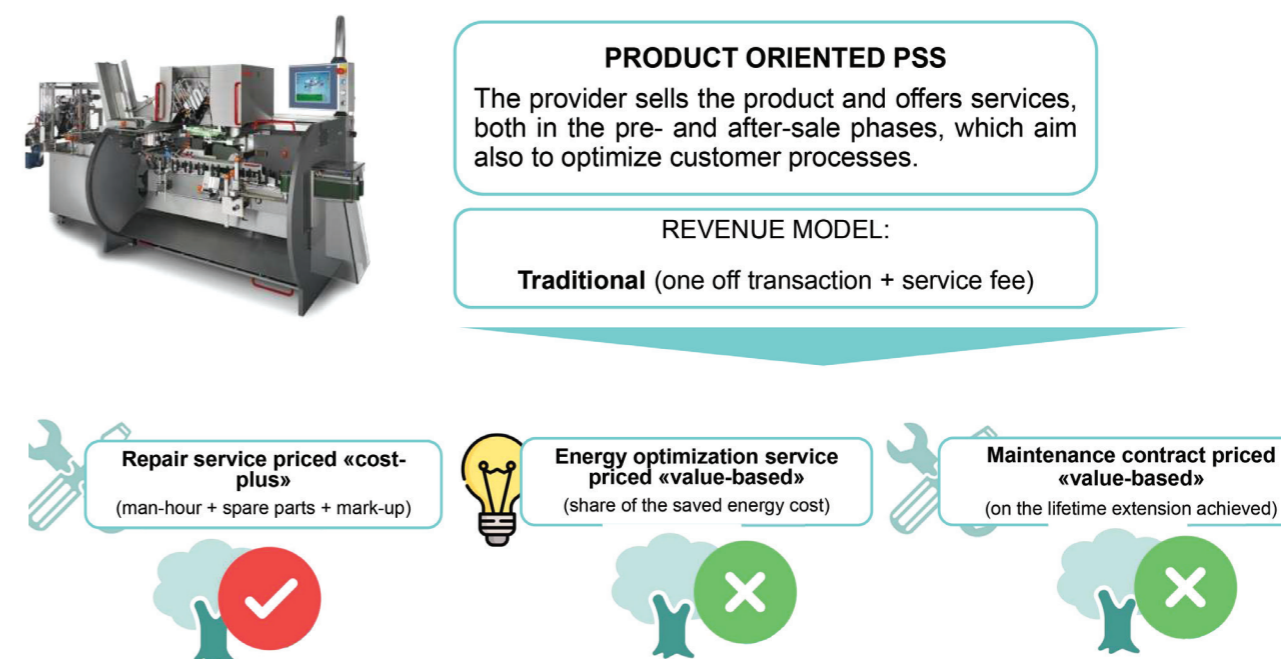


Figure 14 - Alignment and misalignment of pricing mechanisms in Product-oriented business models (Adapted from¹⁷)

that this PSS type provides only **incremental environmental gains**: they derive from improved resource efficiency and extended lifetime of products thanks to maintenance services, and, less frequently, from end-of-life management due to take-back, reconditioning or recycling services. The revenue model is based on a one-off transaction associated to the transfer of product ownership to the customer, and the subsequent sales of services through a transactional or relational approach (e.g. multi-year service contracts). Services are usually priced with a **cost-plus** approach - e.g. repair activities based on manhours, materials, and travel costs of technicians. However, a cost-plus pricing mechanism is not able to capture and align the provider and customer incentives toward positive environmental impact, being based on the inputs introduced in the service process, as illustrated in Figure 14. Conversely, a **value-based pricing** could better align product-oriented PSS to environmental sustainability if the economic

value driver is coherent with the environmental value driver entailed by the service. For instance, an energy optimization service priced on the actual amount of energy saved is aligned with environmental benefits, providing both economic and environmental value. As well, a maintenance contract should be priced in proportion to the lifetime extension that can be achieved through regular maintenance, with the benefits for the customer demonstrated through a **total cost of ownership** viewpoint.

In Use-oriented and Result-oriented servitized business models, we can find several different cases where multiple combinations of the options in Figure 15 co-exist.

At the environmental driver level, in Use-oriented PSS, the provider usually includes services that contribute to extending the product lifecycle, increasing operational efficiency, intensifying

product usage, and facilitating reuse. If the revenue model is a **fixed-fee** (or **pay-per-period**) one, granting access to the asset and its usage, could lead to careless behavior by the customer leading to unnecessary usage that can increase pollution, and to misbehaviors that can shorten the product life or request additional maintenance. On the contrary, **pay-per-use revenue models** discourage unnecessary product use (only if the cost perceived by customers is significant since the customer is freed from the initial investment) and can trigger greater environmental benefits. **Hybrid** revenue models combining a fixed-fee and a variable usage rate may contribute to better align the Use-oriented PSS adoption with a set of environmental value potentials. Per-usage-unit pricing mechanisms should couple an input or value-based logic (to find the right balance between provider's cost and customer benefits) with an **emission-based approach** that incorporates environmental impacts, such as greenhouse gas emissions, in a form similar to a carbon tax¹⁷.

For instance, in a **car-sharing offer** a hybrid revenue model could be set as illustrated in Figure 13. A fixed per-period fee could be charged to balance e.g. maintenance and operational costs borne by the provider, with the opportunity costs for the customers of owning a car (higher environmental impact) or instead of using public transport (lower environmental impact). A pay-per-usage-unit additional cost should be priced according to a criterion connected to the

environmental impact (e.g. kilometers run instead of time) and a mechanism that include input-based (e.g. fuel cost) and emission-based pricing parameters (e.g. a "carbon tax" applied on the input).

In **Result-oriented business models**, a similar guideline should be adopted but with a different revenue model logic. Both pay-per-outcome or pay-per-performance revenue models could be applied, combined - or not - with a limited fixed base fee (that is usually required to protect the provider investment in the relationship). However, the pricing mechanism should incorporate the environmental value driver(s) in order to achieve the environmental potential of the offering, adopting for instance an emission-based pricing mechanism, as described above, that can be coupled with value-based price components. In pay-per-performance, in particular, the expected cost for the customer should be linked to an agreed target of environmental impact, with a premium/penalty mechanism for deviations from that target. This logic ultimately leads to developing an innovative **"pay-per-emission"** revenue model, as a special type of pay-per-performance. This offers a way to incorporate environmental value drivers into a result-oriented PSS by properly combining different pricing mechanisms, among which an emission-based component, so to include environmental externalities.

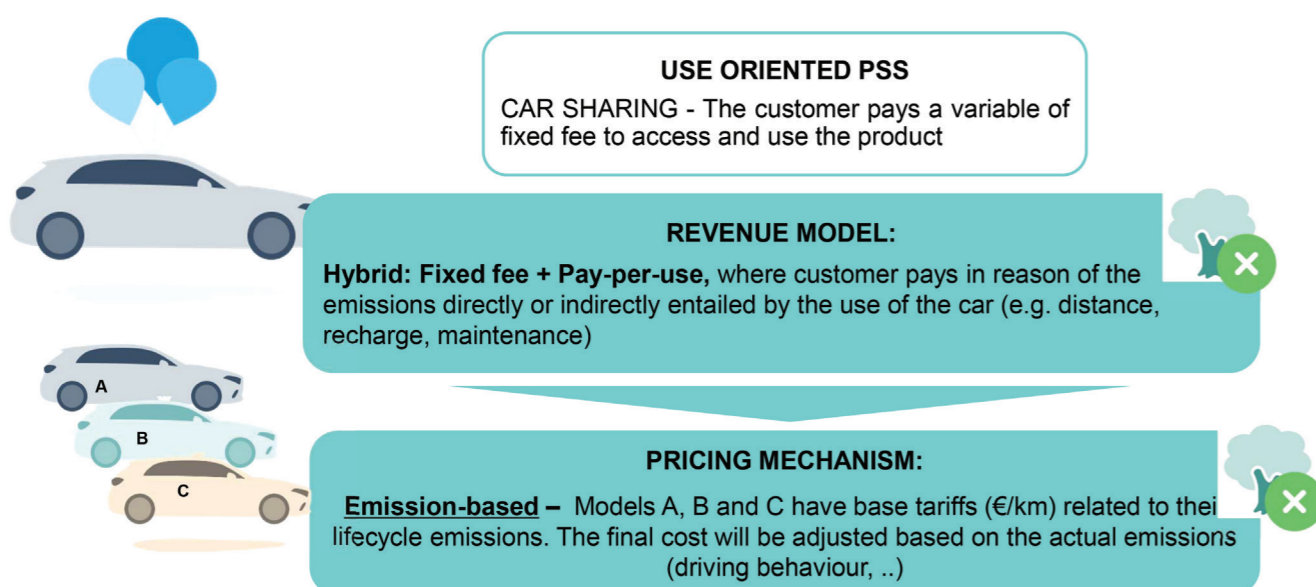


Figure 15 - Example of a car sharing User oriented business model where the revenue and pricing mechanism are aligned with the sustainability potential (Adapted from¹⁷)



Sean O'Neill
Chief Product and Technology Officer, Synchron

Spare parts remanufacturing and price optimization for sustainability

In today's evolving marketplace, sustainability is no longer a buzzword - it is a business imperative. According to the recent Modernizing the Aftermarket report, which surveyed 600 service and supply chain decision makers across Europe and North America, **95% of respondents plan to adopt a circular business model within the next 12-24 months**. This signals a clear shift towards **sustainability in aftermarket operations**, with servitization at the heart of this transformation. Servitization enables companies to move away from traditional product sales to long-term service contracts that prioritize keeping equipment operational for longer periods of time. This approach extends product lifecycles, reduces waste, and supports the closed-loop systems essential to the circular economy. This not only helps manufacturers reduce their environmental impact but also opens the door to new revenue streams with **outcome-based service models**. At Synchron, we are driving this transition with cutting-edge integrated **service lifecycle management software solutions** that enable manufacturers to move from a product-based model to a service-based model, also known as Product-as-a-Service (PaaS). By focusing

on aftermarket services such as parts management, dynamic pricing strategies, and service contract optimization, our solutions help companies optimize resources, minimize waste, and improve customer satisfaction. Through advanced data analytics and AI-driven insights, we enable companies to refine their service offerings, increasing both efficiency and profitability.

Synchron AI-powered pricing solution addresses the complexities of pricing in a service-driven, circular economy. It consolidates contract data into a single platform and acts as a dynamic pricing engine that increases operational efficiency, reduces costs, and **aligns sustainability efforts with financial performance**. By optimizing pricing strategies, companies can better manage resources and achieve sustainability goals without compromising profitability. The takeaway is clear: **profitability and sustainability** are not mutually exclusive. With the right tools, companies can drive sustainable growth while reducing their environmental footprint, proving that a sustainable future is also a profitable one.

Conclusion

Servitization and “as-a-service” business models are acknowledged to increase revenue and profits and develop a competitive advantage for manufacturers or providers, and to increase customer value and satisfaction. World-famous cases such as Rolls Royce’s “Power by the Hour” or Xerox lease and “pay-per-page” have illustrated the benefits of successful servitization and boosted enthusiasm among top managers and researchers about this new business paradigm.

However, servitized business models are still struggling to achieve a large diffusion in the manufactured goods economy. Indeed, servitization requires a **strategic transformation** of the provider firm that shifts the value creation focus from selling products to providing integrated product-service solutions. This radical change in the culture, organization, and activities encounters several obstacles at the provider’s side (among others: an internal “product-oriented” culture; the limited knowledge of the installed base; gaining direct access to end customers; managing the financial impacts of new revenue models) but also at the customer’s one (culture, trust, and ability to share data)³². A plethora of research, practitioners’ books, and successful company cases have indicated ways to address these challenges, and companies are (slowly but progressively) moving forward into this paradigm shift.

In this context, this report focused on the environmental sustainability implications of servitized business models. As shown in this report, **product-, use- and result-oriented servitized business models promise incremental and/or radical**

environmental sustainability benefits, entailed by mechanisms such as product system substitution; resource efficiency, lifetime extension, intensified product usage; increased recycling and reuse; dematerialization and transparency. The growing concerns about climate change and the exploitation of our planet’s finite resources, call therefore with urgency for the widespread adoption of servitized business models, and for the move towards a **performance economy globally**³³.

This report discusses the linkages among servitization, circular economy, and environmental sustainability and the potential that can be unleashed. Some relevant industries are taken as examples and the paths followed by companies belonging to the ASAP community is illustrated. It is shown that in order to fully exploit the sustainability potential of servitization, we need a clear understanding of the mechanisms through which environmental gains can be achieved. The **servitization revolution for sustainability** implies that servitized business models are **purposely designed** to achieve greater environmental improvement, and the trade-offs between business objectives and environmental gains are thoroughly addressed. A sustainability perspective should then be adopted at the **strategic level**. In particular, when designing a servitized offering, companies should define how its content and value proposition enhance one or more environmental value drivers and how this can be translated into **measurable environmental gains**. A subsequent and crucial step is then to design the best-suited **revenue and pricing models** to align with environmental drivers, in order



to achieve the desired environmental outcomes. Managers can act at the revenue and pricing level (for instance redefining the price based on the value of the uptime for the customer or the saved costs thanks to the extended lifetime of the good), or at the revenue model level (e.g., including a fixed fee connected to an agreed availability target that requires the adoption of the maintenance contract) in order to better align the business logic and the environmental benefits. To this aim, companies should also deploy new and purposely designed **pay-per-emission revenue models and emission-based pricing**.

Besides the environmental one, servitization has a great **social sustainability potential**. In particular, this report outlines that servitized models especially **facilitate access** to product-service systems, particularly for marginalized and low-income groups (e.g. through pay-per-use), and fosters the **well-being of local communities**, through the creation of **local jobs** related to lifecycle services, as service delivery is generally more labor-intensive than the production of goods. The social dimension should also be considered in a full-fledged design and development of a company’s servitization strategy.

Finally, a greater awareness of the picture drawn by this report is needed also by institutional and political actors, since they can facilitate the servitization revolution for sustainability by setting norms and regulations that incentivize servitization and its sustainability outcomes.

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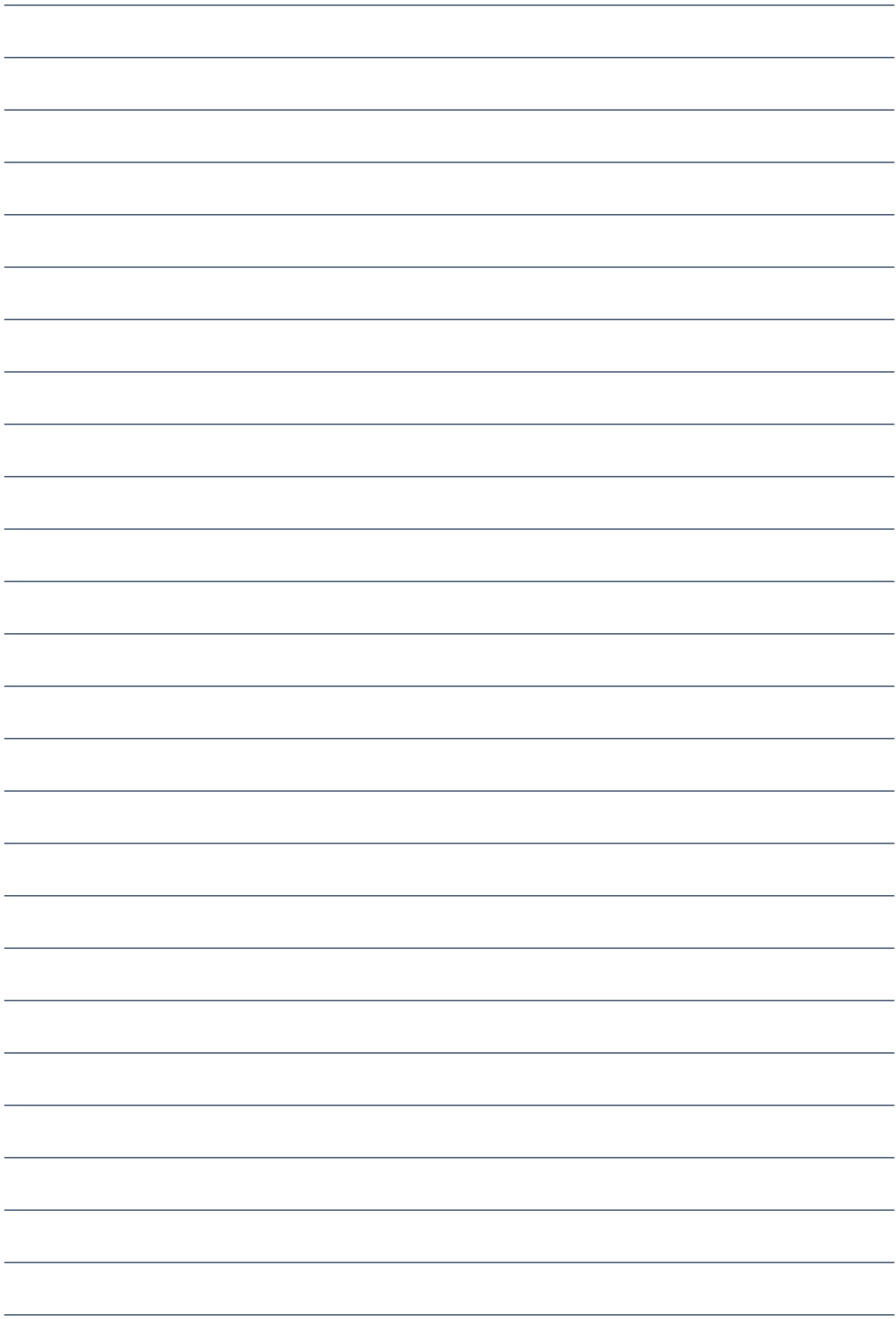
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