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Title of Work: A Systemic Transition to Circular Economy - Business and Technology Perspective

Chapter 3: The design of Sustainable Product-Service Systems to foster Circular Economy for All

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Abstract

The role of design for sustainability to promote a Circular Economy (CE) is increasingly recognized as a key leverage. The CE Action Plan adopted by the European Union in 2020 reports that "up to 80% of products' environmental impacts are determined at the design phase" (European Commission, 2020). The same CE Action Plan recognizes also as a key strategy "incentivizing product-as-a-service or other models where producers keep the ownership of the product or the responsibility for its performance throughout its lifecycle". Indeed, this shift in the offer model has been defined and studied as the Sustainable Product-Service System (S.PSS) since the end of the '90 (Cooper & Evans, 2000; Brezet et al., 2001; UNEP, 2002; Manzini & Vezzoli, 2003; O. Mont, 2004; Tukker, 2004; Baines et al., 2007; Charter & Tischner, 2017).
In this framework, the chapter aims at contributing to how the most updated knowledge on design for sustainability - focusing on S.PSS and their potential win-win benefits - could foster the transition towards a Circular Economy. Moreover, it investigates how recent understanding and research outcomes about S.PSS could position them as promising models to extend the access to goods and services even to low-income contexts, so forth enhancing even social inclusion. Within this understanding, it is hypothesized a new promising role of design in developing S.PSS capable of fostering a sustainable CE for All.

The covered topics follow the learnings of the *LeNSin* international research project funded by the EU Erasmus+ Programme, gathering 36 partner Universities from Mexico, Brasil, South Africa, India, China, and in Europe UK, Finland, The Netherlands, and Italy. The project aimed at developing curricula on Design for Sustainability focused on S.PSS applied to Distributed Economies (DE). The project's preliminary phase, undertaken by all the involved countries, started with desk research, a case studies analysis, and context-specific need analysis, as well as their sustainability benefits and barriers and the role of design in their development. This phase was used to instruct and conduct five country seminars (Mexico, Brazil, South Africa, India, and China) with expert stakeholders. The acquired knowledge was shared among all partners and was

the basis for building a first round of 5 pilot courses in partner universities in the five extra-UE countries. In each course, companies/organizations were involved in verifying both the knowledge-base and the design tools that far developed, by designing sustainable solutions for them. With the knowledge acquired and shared, a second round of 5 pilot courses was organized in the same countries, through different universities/cities. A key outcome is a set of learning resources on S.PSS&DE design for All: the ten full courses (videos and slides of all lectures), case studies, system design tools, and innovative projects. These are available in open access on the LeNS platform (www.lens-international.org).

On the basis of project outcomes, further desk research has been conducted on the existing literature about the main principles, strategies, and business models related to the Circular Economy. Moreover, the analysis of the LeNS international repository (www.lens-international.org) of more than a hundred case studies has been conducted to identify S.PSS cases operating also on a CE level.
With these premises, the chapter makes a step further, investigating the relationship between the abovementioned learnings on S.PSS and the core principles of CE, going beyond the mere association of two concepts: it outlines an updated theoretical framework on why and how S.PSS win-win benefits and design approach can foster the development of circular business models. In particular, why and under which circumstances applying an S.PSS approach to CE makes the economic interest of the producer/provider in designing and developing products & services for extending the technical cycles of materials and products through use intensification, product durability, maintainability/repairability, reusability, enabling remanufacturing and high-quality recycling, as well as extending biological cycles enhancing material biodegradability and resources renewability.
Furthermore, the chapter outlines why an S.PSS is a promising approach to design and offer products & services to foster a CE accessible and preservable over time in low-income contexts, to both final users and entrepreneurs. In particular, why and under which circumstances applying an S.PSS approach to CE, is promising to cut both the initial investment costs and the running cost of maintenance, repair, etc.
Finally, in relation to CE principles and practices, it is given an overview of the applicability of the Method for System Design for Sustainability (MSDS) method and its tools supporting the S.PSS design process. The MSDS method has been developed and refined within a series of projects funded by the European Union and the United Nations Environmental Program (UNEP) since 2002[1].

Keywords: Sustainability, Circular Economy, Product-Service Systems, Design for Sustainability

1. An introduction: System Design for Sustainability as a key enabler for Circular Economy

1.1 Circular Economy and Sustainable Product-Service Systems (S.PSS): synergy of approaches and knowledge base

In the very first place, it is useful to discuss the relationship between S.PSS and the concept of Circular Economy. Although a huge variety of definitions, high research fragmentation, and the blurred contours with the topic of sustainability (Geissdoerfer et al., 2017; Kirchherr et al., 2017; Korhonen et al., 2018), in this context we refer to the Ellen MacArthur Foundation, that originally defined circular economy as *"an industrial economy that is restorative or regenerative by intention and design"* (Ellen MacArthur Foundation, 2013). Starting from this definition, the foundation outlined and refined the concept of Circular Economy over the years, and nowadays it is summarized by three key principles (Ellen MacArthur Foundation, 2021):

[1] International public funded project contributing to the development and refinement of actual MSDS method with its set of support tools:

- MEPSS: MEthodology for Product Service System development (EU funded V FP project, 2002–2005).
- Design for Sustainability (D4S): A Step-By-Step Approach (UNEP funded, 2005–2009)
- LeNS: Learning Network on Sustainability (EU funded Asia-Link project, 2008–2010).
- LeNSes: Learning Network on Sustainable energy system, focused on System Design for Sustainable Energy for all (EU funded EdulinkII project, 2013–2016).
- LeNSin: international Learning Network of networks on Sustainable, focused on designing S.PSS applied to DE as a promising approach for designing sustainability for all (EU funded Erasmus+ project, 2015–2019).

- *Design out waste and pollution*, i.e. to intervene at the design stage to prevent the generation of waste and pollution in the first place.
- *Keep products and materials in use*, i.e. to design products and components to extend their lifespan through practices like maintenance, repair, reuse, re-manufacturing, or – for materials – recycling.
- *Regenerate natural systems*, i.e. not only to reduce the consumption of natural resources, but also to return those resources as a benefit for the environment.

As noted by some authors, even if the concept of circular economy has been popularized and branded by Dame Ellen MacArthur, it can be considered as an umbrella concept that encompasses different principles that have been around for a long time, e.g. industrial ecology, biomimicry and cradle-to-cradle (Ceschin & Gaziulusoy, 2016, 2019). Indeed, CE has been debated and - by some authors - considered a holistic approach to gather the sustainability challenges of the current economic development (Stahel, 2019; Stahel & MacArthur, 2019), though, in the opinion of the authors, some issues like energy resources reduction and the whole socio-ethical dimension of sustainability are not clearly focused by the CE paradigm shift. This chapter is not aimed at deepening this debate, better still the synergies between S.PSS design and Circular Economy models.

To understand the relevance of S.PSS design in enabling and fostering a Circular Economy, is useful to introduce how the latter relates to business and offer models like S.PSS. As noted by Ceschin & Gaziulusoy (2019), with the popularization of the circular economy concept, the term circular business model (Nußholz, 2017) has gradually emerged. Through the definition of a strategy framework for circular business models, Bocken et al. (2016) have proposed six strategies, grouped into two main categories:

- *strategies for slowing loops*, which include extending product value, classic long-life model and encouraging sufficiency;
- *and strategies for closing loops*, which include extending resource value and industrial symbiosis.

More recently, also the importance of intensifying the use phase of products and dematerializing resource loops (replacing products with access to performances) have been emphasized as enablers for circular business models (Geissdoerfer et al., 2018).
A first interesting overlap between S.PSS and circular business models can be noticed by considering 'slowing the loops' and 'dematerializing resource loops': all these approaches were introduced in the late nineties within the definition of PSS and have evolved along the last twenty years toward the key concept behind S.PSS, which is to decouple the creation of value from resource consumption and negative environmental impact (Cooper & Evans, 2000; Brezet et al., 2001; UNEP, 2002; Manzini & Vezzoli, 2003; O. Mont, 2004; Tukker, 2004; Baines et al., 2007; Charter & Tischner, 2017). As regards the concept of closing resource loops and industrial symbiosis - e.g. collection of otherwise 'wasted' materials/resources to turn them into new forms of value (Bocken et al., 2016), a connection can be acknowledged with some recently updated strategies for S.PSS design, that are already considering the development of industrial symbiotic partnerships (Vezzoli et al., 2021).

Similar synergies and mutual enabling frameworks have been acknowledged by other authors in the specific domain of S.PSS & CE. In general, PSS are often proposed as models to foster a Circular Economy (Tukker, 2015). More specifically, some authors have worked on favorable approaches and strategies: Kjaer et al. (2018) have identified a framework based on PSS enablers and requirements to ensure the absolute decoupling of resource consumption and value creation. Pieroni et al. (2019) have defined key conditions to be fulfilled in order to develop CE-Oriented business models based on PSS, while Hernandez (2019) highlighted the need to focus on the development of external systemic conditions before pushing on the application of S.PSS and CE business models within companies. Another bunch of authors focused on a more verticalized level, discussing the potential of S.PSS and Circular Economies in specific domains, like housing (Ghafoor et al., 2023), washing machines (Bressanelli et al., 2017) and mobile phones (Hobson et al., 2018).
Despite the abundance of synergies in terms of key concepts and general approaches, a lack of knowledge base – that the chapter contributes to fill - has been identified regarding the potential compatibility of the two models in terms of design approaches, especially taking S.PSS design as an enabler for Circular Economy.

Moreover, as previously mentioned, since S.PSSs started to be studied also as valuable offer models to foster social equity and inclusion (Vezzoli et al., 2021) - specifically for what concerns the extended accessibility to goods and services – their application in relation to circular business models could enhance social inclusion and prosperity also in a Circular Economy framework. Indeed, the social dimension of the circular economy is being increasingly studied, as well as its socio-ethical sustainability benefits (Padilla-Rivera et al., 2020; Piesik et al., 2018; Social Circular Economy, 2018).
The following paragraphs present the concept of S.PSS as a valuable enabler of any circular economy and enhancing its value in terms of social equity and inclusion, going in coherence – and even beyond - the strategies defined by the abovementioned "EU Circular Economy Action Plan" (European Commission, 2020).

2. Sustainable Product-Service Systems (S.PSS): an opportunity to foster Circular Economy businesses and technologies

2.1. Sustainable Product-Service System: A Win-Win Opportunity for Sustainability

As anticipated, the concept of Sustainable Product-Service System (S.PSS) has been studied since the end of the 1990s as a promising offer/business model capable of creating (new) value, decoupling it from material and energy consumption. In other words, significantly reducing the environmental impact of traditional production/consumption systems.

More recently, S.PSS has been demonstrated (Vezzoli, 2010; Vezzoli et al., 2018) to be a clearly promising offer model to extend access to goods and services even to low- and middle-income contexts, thus enhancing social equity and cohesion as well.
Finally, it is a win-win offer model combining the three dimensions of sustainability, the economic the environmental, and the socio-ethical. An S.PSS can be defined as follows (Vezzoli et al., 2021):

> ***A Sustainable Product-Service System (S.PSS) is an offer model providing an integrated mix of products and services that are together able to fulfill a particular customer/user demand (to deliver a "unit of satisfaction"), based on innovative interactions between the stakeholders of the value production system (satisfaction system), where the ownership of the product/s and/or the life cycle services costs/responsibilities remain with the provider/s, so that the same provider/s continuously seek/s environmentally and/or socio-ethically beneficial new solutions, with economic benefits.***

S.PSSs are value propositions introducing considerable innovation on different levels (see also Fig. 1), which are besides aligned with the approach adopted by the European Union within the Circular Economy Action Plan (2020):

- They shift the business focus from selling (only) **products** to offering a so-called "**unit of satisfaction**"[2], i.e. a combination of products and services jointly capable of achieving ultimate user satisfaction.
- They shift the value perceived by the customer/end-user from **individual ownership** to **access** to goods and services.
- They shift the primary innovation from a **technological** one to an innovation on a **stakeholder interaction** level.

[2] The Unit of Satisfaction has been defined as (Vezzoli et. al., 2018): *"a defined (quantified) satisfaction of a customer that could be fulfilled by one or more mix of products and services, used as a reference unit to design and to evaluate the sustainability benefits and impacts"*

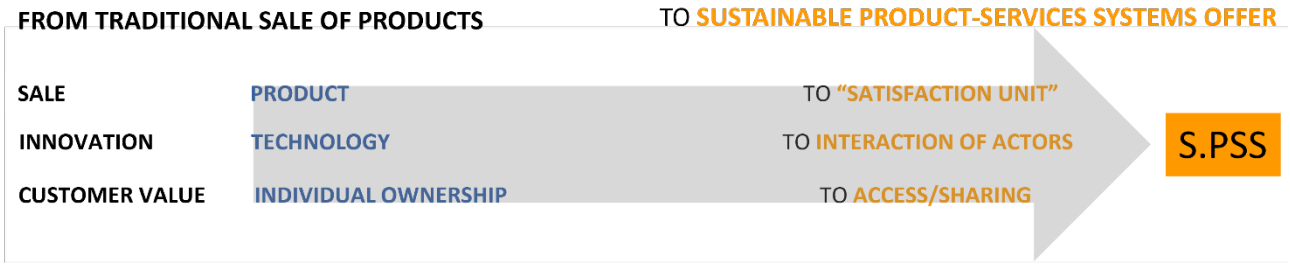

Fig. 1 S.PSS: a paradigm shift from a traditional product offer (Vezzoli et al., 2021)

Finally, in the key understanding of our discourse, S.PSSs are offer models with a win-win sustainability potential, i.e. they are offer/business models capable of creating (new) value, decoupling it from resource consumption and increase of negative environmental impact whilst extending access to good and services to low- and middle-income people and, at the same time, enhancing social equity and cohesion.

1.2 S.PSS applied to CE: examples and Types

Three main S.PSS approaches to system innovation have been studied, adapted, and listed as favorable for eco-efficiency and indeed well fit even for the circular economy approach (Hockerts & Weaver, 2002; UNEP, 2002; Tukker, 2004; Vezzoli et al., 2014), and they can be adapted as below:

1. *CE Product-oriented S.PSS*: offer model providing added value to the product life cycle (either technical and/or biological).
2. *CE Use-oriented S.PSS*: offer model providing "enabling platforms" for customers.
3. *CE Result-oriented S.PSS*: offer model services providing "final results" for customers.

EXAMPLE

Herman Miller – Twelve years service[3]

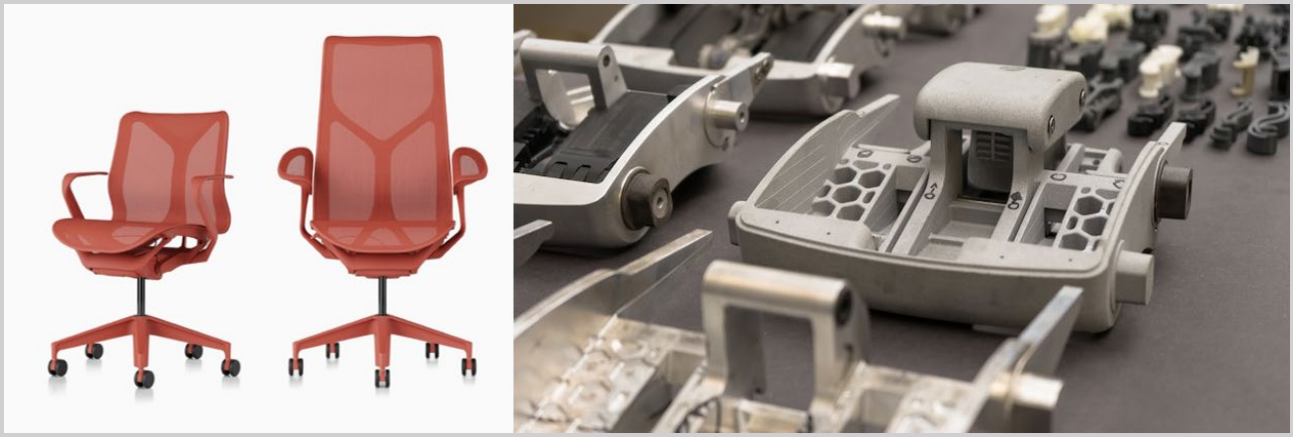

Fig. 2 Example of a Herman Miller chair with a twelve-year warranty (CE Product-oriented S.PSS)

Aeron and other chairs sold by Herman Miller have a 12-years warranty. During the warranty period, Herman Miller promotes CE models by offering the repairs or replacing (at its option) any product, part, or component that fails as a result of a defect in material or workmanship, with a comparable product, part, or component. This additional service is in turn complemented with appropriate design to extend the lifespan of the product.

[3] Available on www.lens-international.org

The presented case is an example of Product-oriented S.PSS applied to Circular Economy principles, i.e. through the extension of the product's technical cycle through the practices of repair and reuse of components. In the following lines, we see how – and with which characterizations - the different S.PSS approaches can be valuable within a Circular Economy framework.

CE Product-oriented S.PSS (type I): adding value to the product life cycle (either technical and/or biological)

In summary, a ***CE Product-oriented S.PSS*** *innovation* adding value to the product life cycle is defined as (adapted from Vezzoli et al., 2021):

> ***a company/organization (alliance of companies/organizations) that provides all-inclusive life cycle services – maintenance, repair, reuse, re-manufacturing, and product take-back (for recycling/composting and/ or energy recovery) – to guarantee the life cycle performance of the product/semi-finished product (sold to the customer/user) and its materials.***

A typical contract would include services aimed at regenerating the technical cycle (e.g. maintenance, repair, reuse, re-manufacturing, recycling) or restoring the biological cycle of a product (e.g. take-back services aimed at composting or energy recovery) over a specified period of time. The customer/user responsibility is reduced to the use and/or disposal of the product/semi-finished product (owned by the customer), since she/he pays all-inclusively for the product with its life cycle services, and the innovative interaction between the company/organization and the customer/user drives the company/organization's economic interest in continuously seeking circular economy principles and practices (environmentally beneficial new solutions), i.e. the economic interest becomes something other than only selling a larger amount of products.

CE Use-oriented S.PSS: offering enabling platforms for customers (type II)

In summary, a ***CE use-oriented S.PSS*** *innovation* offering an enabling platform to customers is defined as:

> ***a company/organization (alliance of companies/organizations) that provides access to products, tools and opportunities enabling the customer to get their "satisfaction". The customer/user does not own the product/s but operates them to obtain a specific "satisfaction" (and pays only for the use of the product/s).***

Depending on the contract agreement, the customer/user could have the right to hold the product/s for a given period of time (several continuous uses) or only for one use.

Commercial structures for providing such services include sharing, collective use (as well as other variations like pooling or leasing) of certain goods for a specific use. The customer/user consequently does not own the products, but operates on them to obtain a specific final satisfaction (the client pays for the use of the product). Again, in this case, the innovative interaction between the company/organization and the customer/user drives the company/organization to continuously seek circular economy principles and practices (environmentally beneficial new solutions) together with economic benefits, e.g. to design long-lasting products[4] that are easy to maintain, repair, reuse, re-manufacture and recycle.

CE Result-oriented S.PSS: offering final results to customers (type III)

A ***CE result-oriented S.PSS*** *innovation* offering final results to customers can be defined as:

[4] In relation to Use-oriented and Result-oriented S.PSS, a potential win-win benefit could be also fostering the design for products' resources minimization, specifically when the producer/provider is also owner/responsible for resource consumption (Vezzoli et. al, 2021).

a company/organization (alliance of companies/organizations) that offers a customized mix of services, instead of products, in order to provide a specific final result to the customer. The customer/user does not own the products and does not operate on them to obtain the final satisfaction (the customer pays the company/organization to provide the agreed results).

The customer/user benefits by being freed from the problems and costs involved in the acquisition, use and maintenance of equipment and products. The innovative interaction between the company and the customer/user drives the company's economic and competitive interest to continuously seek circular economy principles and practices (environmentally beneficial new solutions), e.g. products that are easy to maintain, repair, reuse, re-manufacture, and recycle.

3. S.PSS win-win promising benefits to diffuse Circular Economy solutions

When is an S.PSS eco-efficient and how it foster circular strategies, so forth decreasing damaging environmental impacts?

In other words, why and when is an S.PSS producer/provider economically incentivized in designing for environmental sustainability within a CE framework? The following S.PSS & CE environmental and economic win-win benefits could be highlighted, as a specification of the conducted desk research on S.PSS general win-win strategies and based on the case study analysis that has been carried out, supported by brainstorming sessions with experts (adapted from Vezzoli et al., 2018):

3.1. Benefits related to products' technical cycle

(a) *Product technical cycle extension*: As far as the S.PSS provider is offering the products retaining the ownership and being paid per *unit of satisfaction*, or offering all- inclusive product with services for its maintenance, repair, reuse, and/or re-manufacturing, the **longer** the product/s or its components' technical cycle last (environmental benefits), and the **more** the producer/provider avoids or postpones the disposal costs plus the costs of pre-production, production and distribution[2] of a new product substituting the one disposed of (economic benefits). Hence the producer/providers are driven by economic interests to design (offer) for extending products' technical cycle, e.g. through maintenance/repair and/or reuse and/or re-manufacturing/refurbishment (which has implications in terms of eco-efficient design for circularity) (Fig. 3).

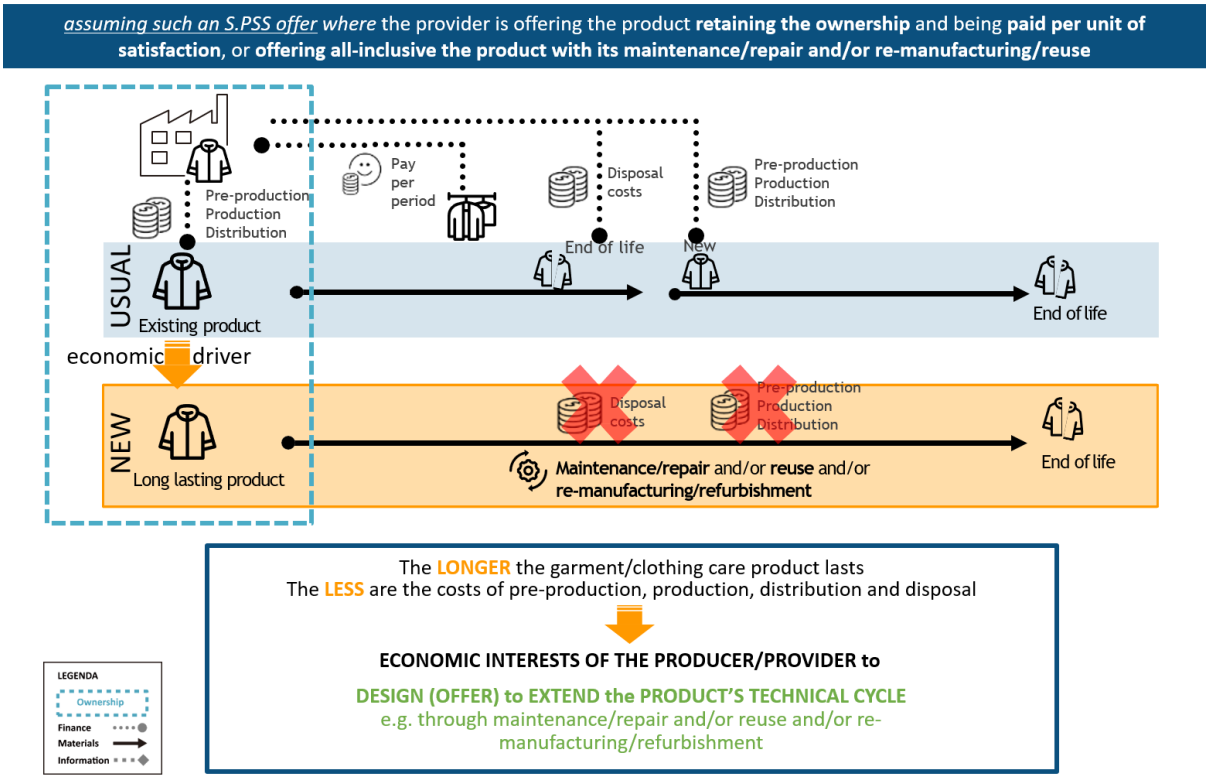

Fig. 3 S.PSS applied to a CE model fostering the design (offer) for the extension of product's technical cycle (adapted form Vezzoli et al., 2021)

(b) *Intensive use of products*: As far as the S.PSS provider is selling a shared or collective use of products (or product's components) to various users, the **more** intensively the product/s (or some product's components) are used, i.e. the more time within their technical cycle (environmental benefits), the **higher** the profit, i.e. proportionally to the overall use time (economic benefits). Hence, the producers/providers are driven by economic interests to design for intensifying the products' technical cycle e.g. through shared and/or collective use modes (which has implications in terms of eco-efficient design for circularity) (Fig. 4).

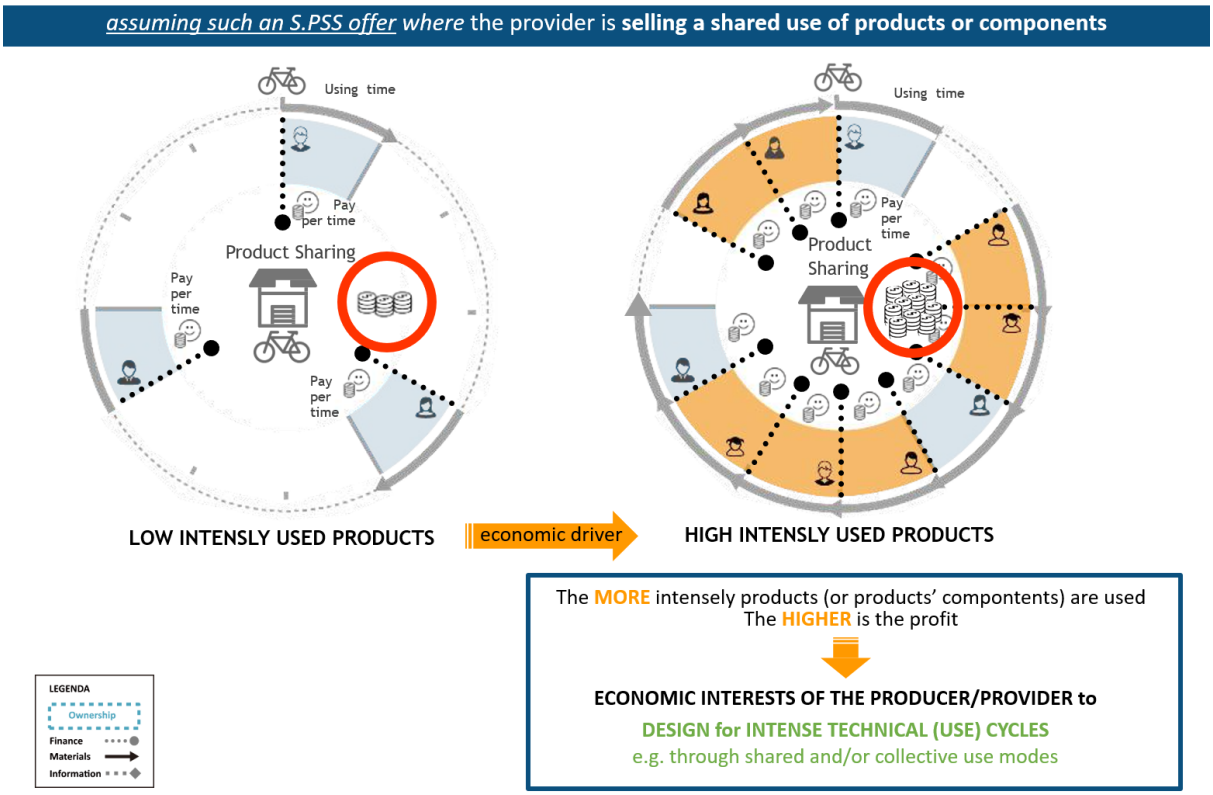

Fig. 4 S.PSS applied to a CE model fostering the design (offer) for intensive technical (use) cycles (adapted from Vezzoli et al., 2021)

(c) *Material technical cycles extension*: As far as the S.PSS provider is selling the product all-inclusive with its end-of-life treatment/s, the **more** the materials are recycled (environmental benefit), the **more** costs are avoided of both landfilling and the purchase of new primary materials. Hence, the producer/provider is driven by economic interests to design for extending the materials' technical cycle, i.e. recycling (which has implications on eco-efficient design for circularity) (Fig. 5).

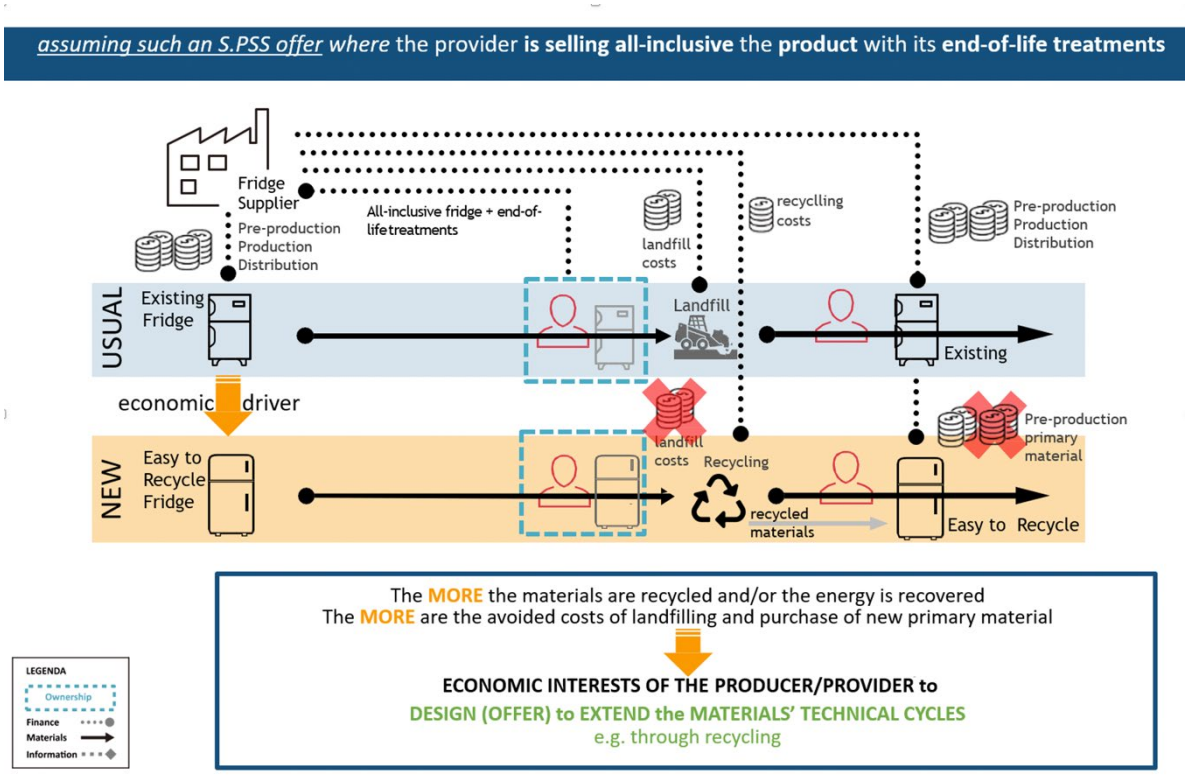

Fig. 5 S.PSS applied to a CE model fostering the design (offer) for the extension of materials' technical cycles (recycling) (adapted form Vezzoli et al., 2021)

3.2. Benefits related to products' biological cycle

(d) *Resources' renewability*: When the S.PSS provider has an all-inclusive offer of a utility, with pay per period/time/satisfaction (e.g. energy production unit ownership by the producer/supplier), the **higher** the proportion of passive/renewable sources is in relation to non-passive/non-renewable (environmental benefits), and the **higher** is the profit, i.e. the payment minus (among others) the costs of non-passive/non-renewable sources (economic benefits). Hence, the producer/provider is driven by economic interests to design (offer) to extend the biological cycles e.g. through regenerative flow management of resources and/or cascade approach (which has implications in terms of eco-efficient design for circularity) (Fig. 6).

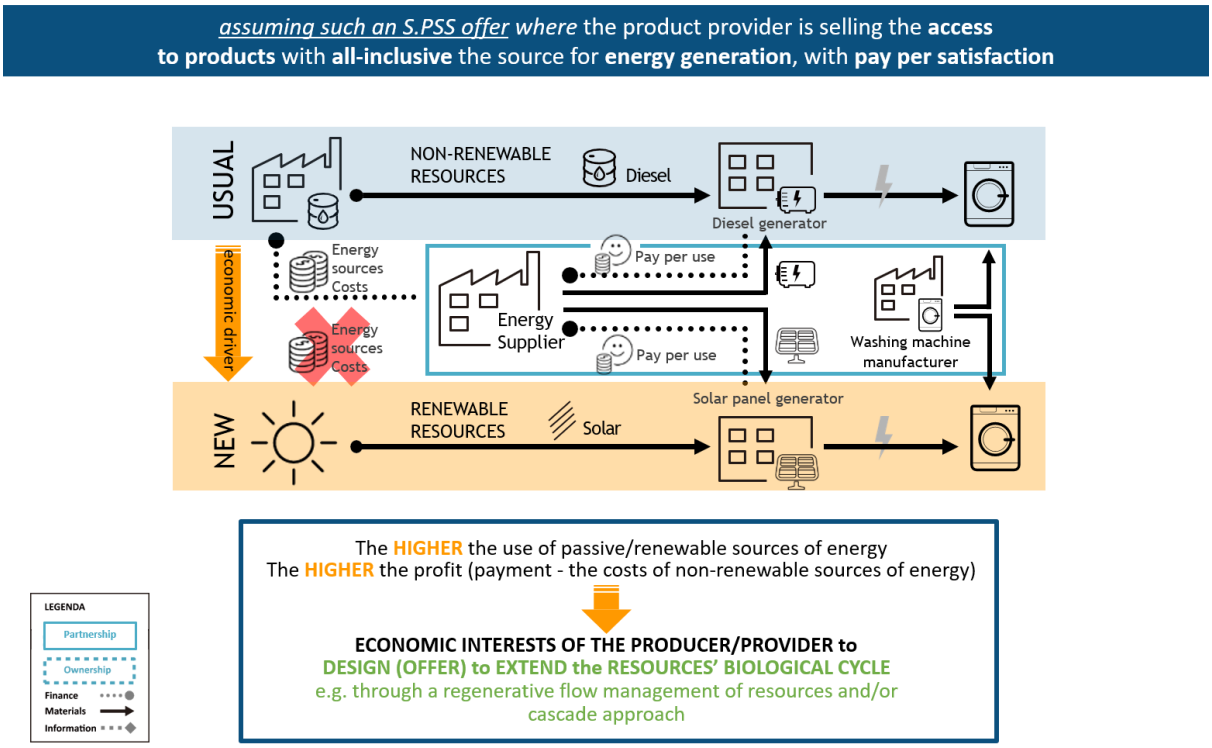

Fig. 6 S.PSS applied to a CE model fostering the design (offer) for passive/renewable resource optimization to extend the resources' biological cycle (adapted from Vezzoli et al., 2021)

(e) *Material biological cycles extension*: As far as the S.PSS provider is selling the product all-inclusive with its end-of-life treatment/s, the **more** the materials are either composted or processed with renewable energy recovery (environmental benefits), the **more** costs are avoided of either landfilling or the purchasing of new primary compost or energy (economic benefits). Hence, the producer/provider is driven by economic interests to design for extending the materials' biological cycles, i.e. through composting or renewable energy recovery (which has implications on eco-efficient design for circularity) (Fig. 7).

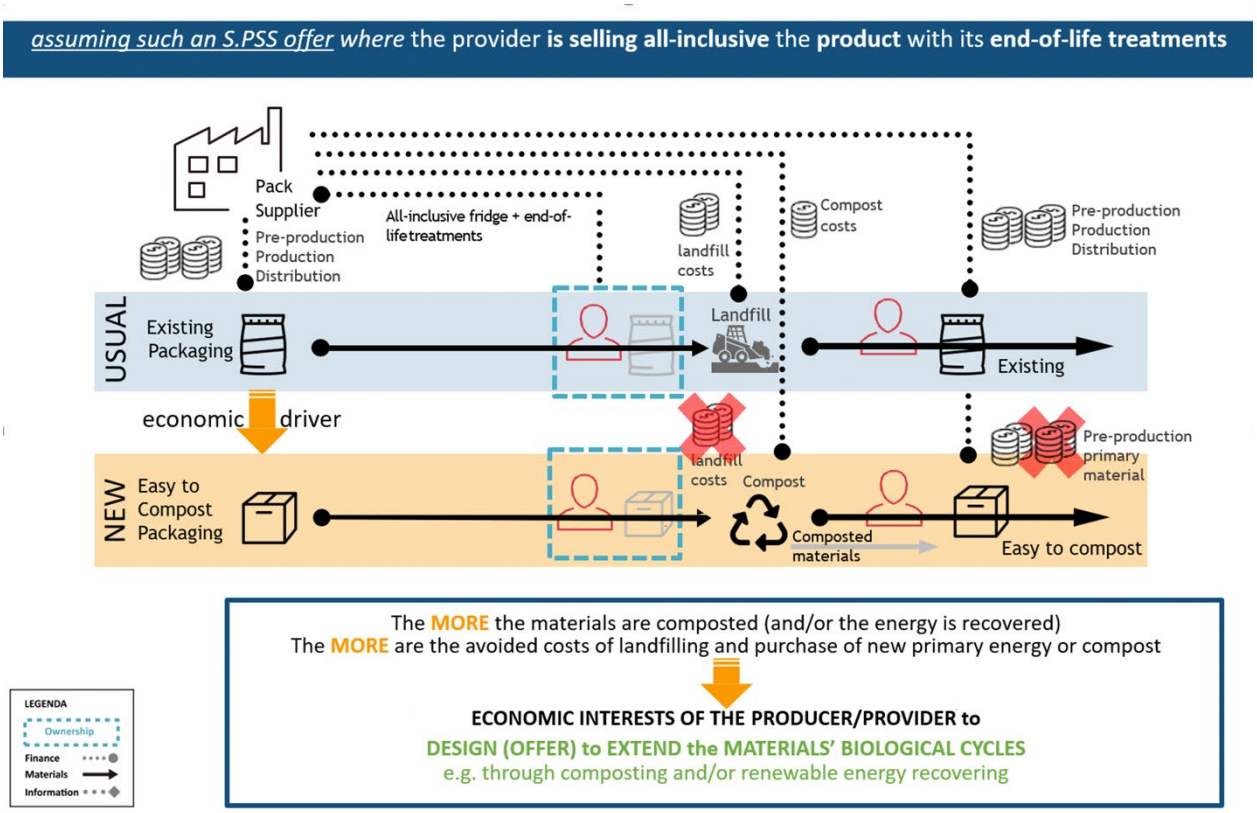

Fig. 7 S.PSS applied to a CE model fostering the design (offer) for the extension of materials' biological cycles (composting or renewable energy recovery) (adapted from Vezzoli et al., 2021)

To conclude, when does an S.PSS make eco-efficient an offer within the Circular Economy framework? When the product ownership and/or the economic responsibility for its life cycle performance remains with the producers/providers who are selling a unit of satisfaction rather than (only) the product. And why does this happen? Because this way, we shift or allocate the direct economic and competitive interest to reduce the products' and/or the services' environmental impacts, onto the stakeholder responsible for their design and development. Consequently, within an S.PSS model, a product design embracing Circular Economy principles and practices is economically beneficial (Fig. 8).

In other words, an S.PSS producer/provider is economically interested in:

- *Design out waste and pollution*
- *Design to keep products and materials in use*
- *Design to regenerate natural systems.*

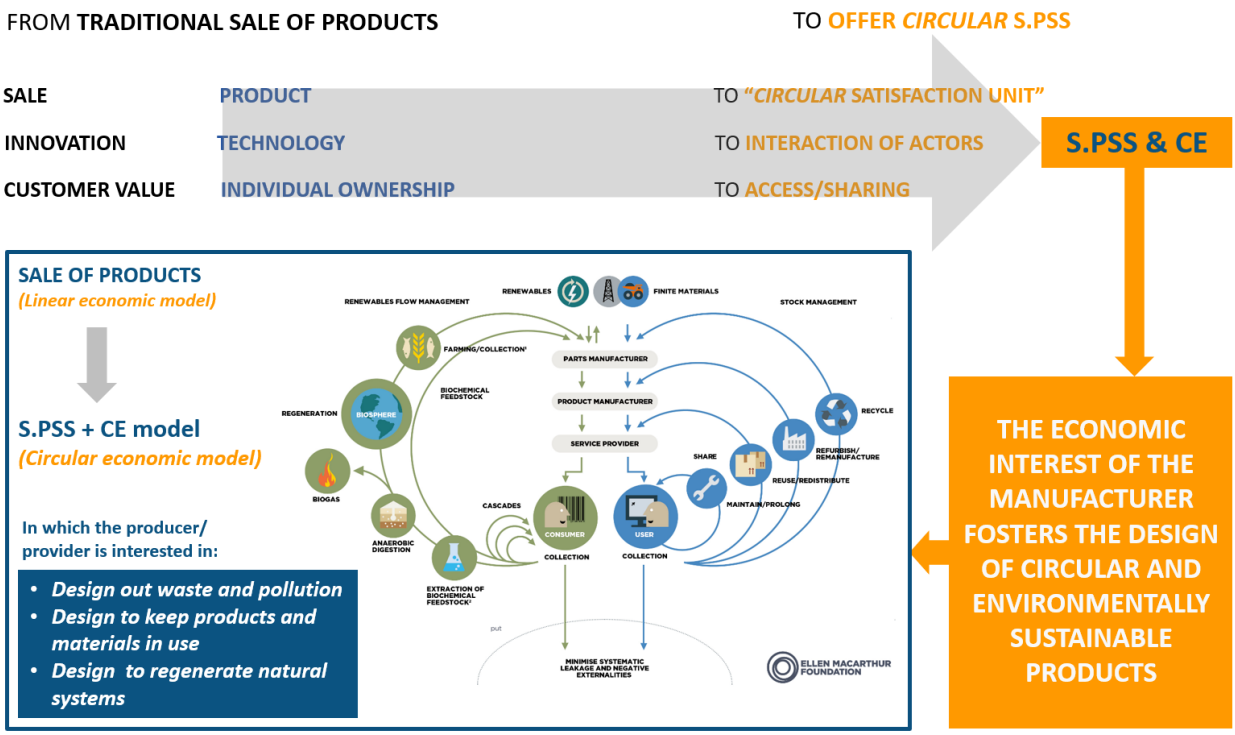

Fig. 8 S.PSS as a model making product design for Circularity economically beneficial for the manufacturer/provider

4. S.PSS win-win promising benefits to make Circular Economy solutions accessible for All

The social dimension of circular economy is being increasingly studied, as well as its socio-ethical sustainability benefits (Padilla-Rivera et al., 2020; Piesik et al., 2018; Social Circular Economy, 2018). May S.PSS applied to the Circular Economy framework foster also socio-ethical benefits? It has been studied (Vezzoli et al., 2021) that S.PSSs - if properly conceived - are opportunities to make goods and services economically accessible and preservable over time to both final users and entrepreneurs/organizations, also in low- and middle-income contexts (i.e. by cutting/reducing initial costs and cutting/reducing life cycle costs).

Indeed, as far as S.PSS can be applied in a Circular Economy offer of ownerless products and/or with all-inclusive life cycle costs, the following S.PSS socio-ethical and economic win-win benefits could be highlighted as enabling a sustainable circular economy for all (updated from Vezzoli et al., 2018). The first two are related to end-users and the third, fourth, and fifth are related to entrepreneurs/organizations:

(a) *End-user product accessibility*: As far as an S.PSS model is applied to a Circular Economy by selling the access rather than mere product ownership, this reduces or avoids purchasing costs of products that are frequently too high for low- and middle-income end-users *(economic benefits),* i.e. making goods and services more easily accessible (*socio-ethical benefits*) (Fig. 9).

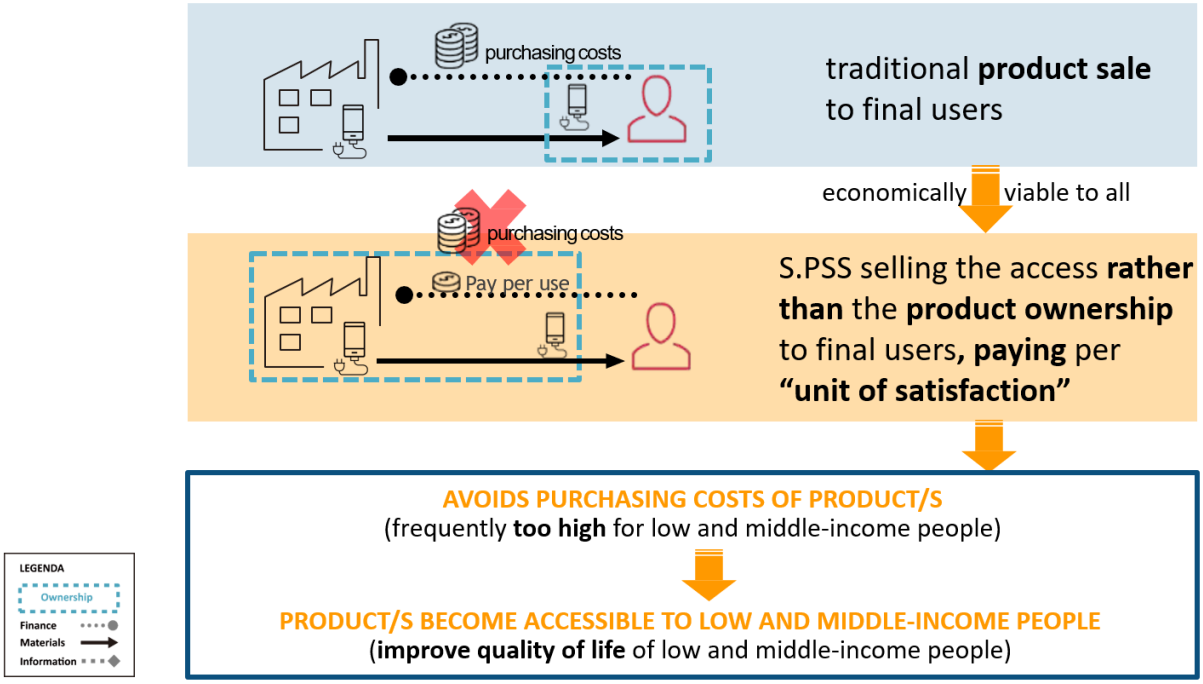

Fig. 9 S.PSS applied to a CE as a model making product/s accessible to low- and middle-income end-users (adapted form Vezzoli et al., 2021).

(b) *Reduction of interrupted product use*: As far as an S.PSS model is applied to a Circular Economy by selling the 'unit of satisfaction' including life cycle services costs, this reduces or avoids running costs for maintenance, repair, reuse, and re-manufacturing, that are too high for low- and middle-income end-users (economic benefits), i.e. who can avoid interruption of product use (socio-ethical benefits) (Fig. 10).

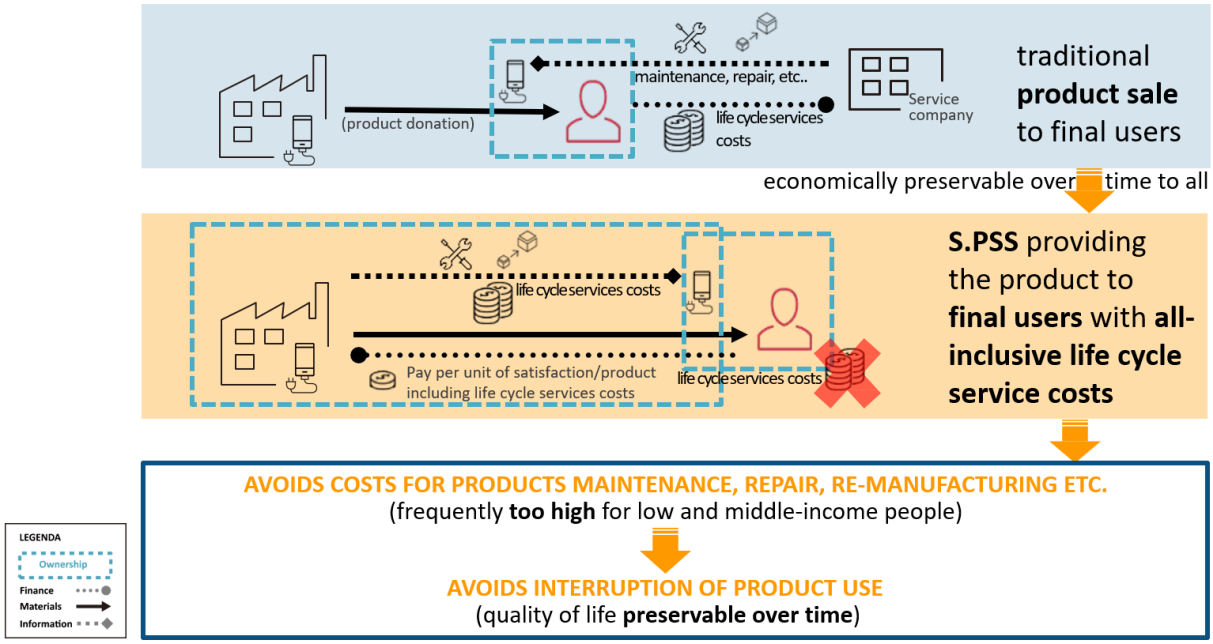

Fig. 10 S.PSS applied to a CE as a model making quality of life preservable over time in low- and middle-income contexts (adapted from Vezzoli et al., 2021).

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(c) *Entrepreneurs/organizations' equipment accessibility*: As far as the S.PSS model is applied to a Circular Economy by selling access rather than the (working) equipment itself, this reduces or avoids initial (capital) investment costs of equipment, which are frequently too high for low- and middle-income entrepreneurs/organizations (economic benefits), i.e. facilitating new business start-ups in low- and middle-income contexts (socio-ethical benefits) (Fig. 11).

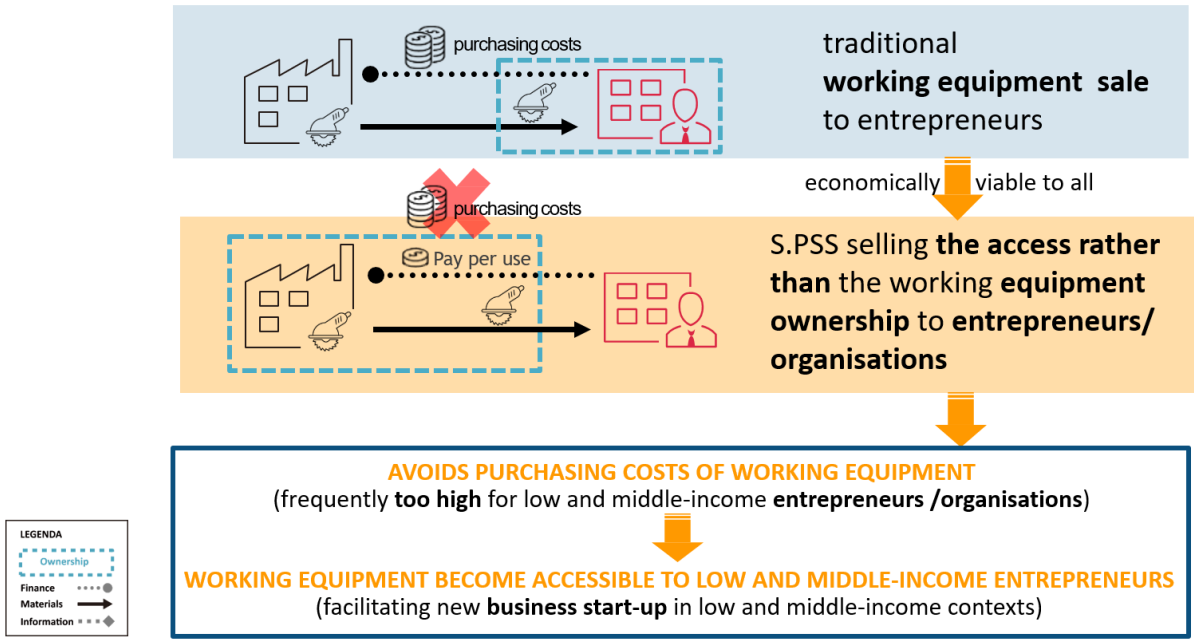

Fig. 11 S.PSS applied to a CE model facilitating new business start-ups in low- and middle-income contexts (adapted form Vezzoli et al., 2021).

(d) *Reduction of interrupted equipment use*: As far as the S.PSS model is applied to a Circular Economy by selling all-inclusive life cycle services with the equipment offered to entrepreneurs, this reduces or avoids running costs for equipment maintenance, repair, reuse, re-manufacturing, etc. that are frequently too high for low- and middle-income entrepreneurs/organizations (economic benefits), i.e. this avoids interruption of equipment use and subsequently working activities (socio-ethical benefits) (Fig. 12).

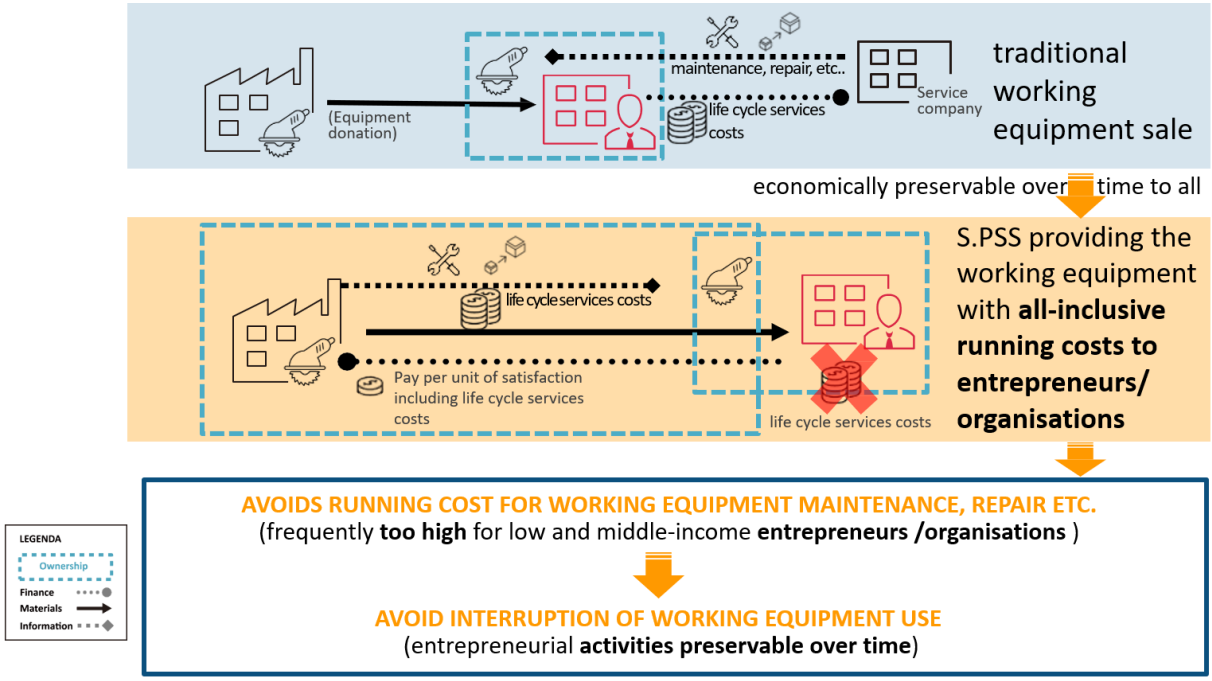

Fig. 12 S.PSS applied to a CE model making entrepreneurial activities preservable over time (adapted from Vezzoli et al., 2021).

(e) *Local employment and competencies improvement*: As far as an S.PSS model is applied to a Circular Economy by offering goods and services without product purchasing costs, they open new market opportunities for local entrepreneurs via new potential low- and middle-income customers, i.e. potentially empowering locally based economies and life quality (socio-ethical benefits) (Fig. 13).

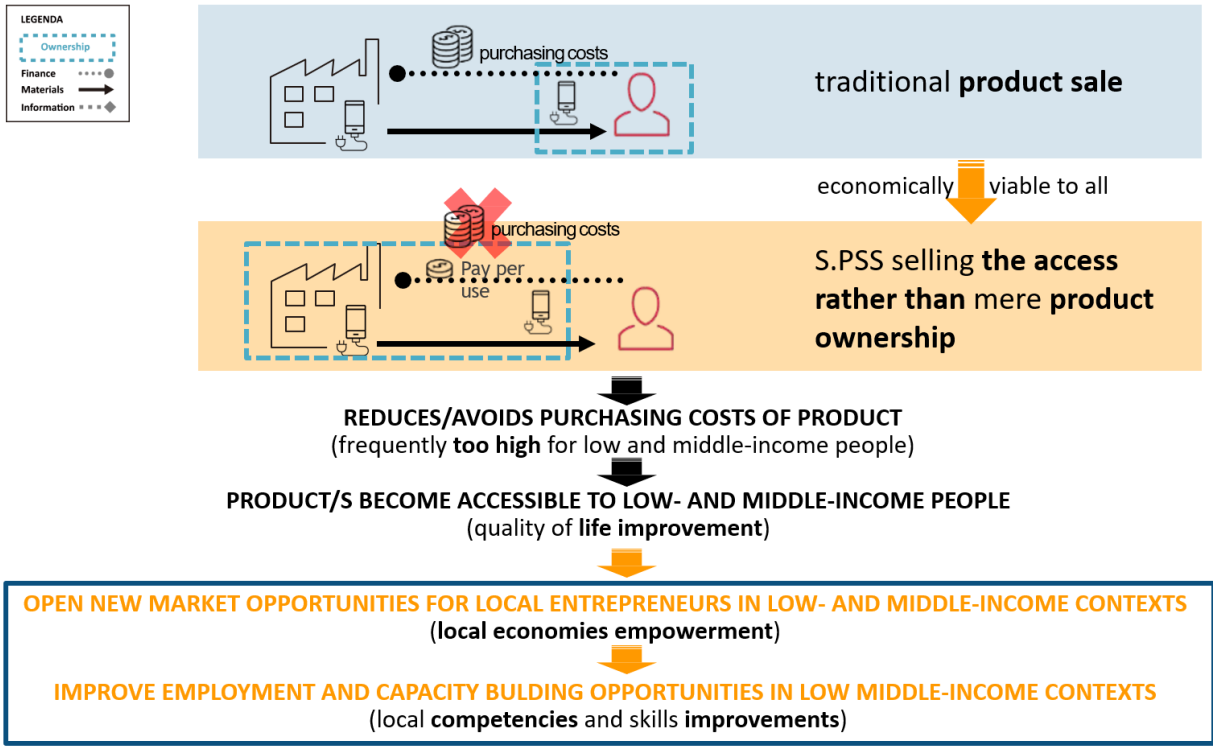

Fig. 13 S.PSS applied to a CE model improving local employment, competencies, and skills

Due to the presented benefits, as well as for their inherent principles, S.PSS are also aligned with business approaches which are considered to be promising for the Bottom of the Pyramid (BoP). Indeed, like for other business models (e.g. Natural capitalism, social enterprises, closed-loop models), being sustainability – in its environmental, social and economic pillars - directly connected with the overall economic interest, the concept of poverty gets considered in its whole complexity as a systemic issue, and not just as a matter of economic disadvantage (Dembek et al., 2018).

In particular, the service dimension of an S.PSS is suitable for local providers, thus generating local jobs related to the Circular Economy. This contributes directly to social cohesion, as it reduces the need for migration or long commutes; this also increases the likelihood of a better balance between work and social life; and thus provides a context where the social fabric can be built up and/or consolidated. All this considered, S.PSS potentially facilitates both the delivery and the sourcing of CE products and services for BoP communities, which are recognized as promising approaches to generating value on a system level (Dembek et al., 2018)

Finally, within a CE framework adopting an S.PSS model the producer/provider is economically incentivized in designing for social equity, i.e. to extend sustainable access to products/equipment for low- and middle-income people (see Fig. 14), by designing for:

- improving the quality of life of low- and middle-income people through economically accessible goods and services preservable over time;
- supporting new business start-ups and their survival over time in low- and middle-income contexts; empowering local economies by improving competencies and skills.

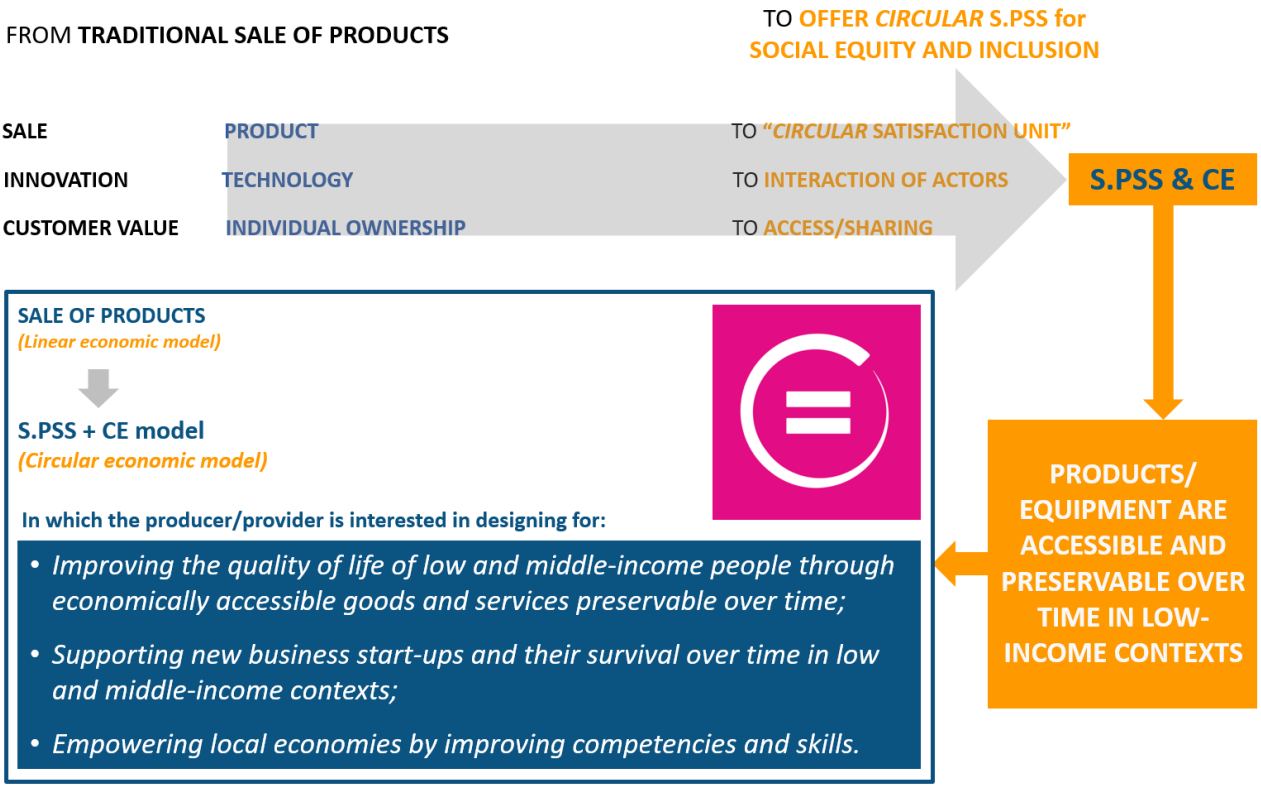

Fig. 14 S.PSS applied to a CE as a model making the design of accessible and preservable products/equipment economically relevant for the manufacturer/provider

Though S.PSS can be considered promising to enable CE business models for all - also within low-income contexts - there are still some potential barriers to be addressed, especially considering poverty as a complex and systemic problem. Indeed, even if S.PSS potentially facilitates access to products and services over time as well as empowers local communities with competencies and skills, they don't consider specific factors like psychosocial issues, knowledge deprivation or adverse power relationships, which could affect communities' response toward the success of a business model (Arora & Romijn, 2011; Nakata & Weidner, 2012)

Said this, it is also true that S.PSS can be designed in combination with other business models and system approaches, and so forth integrating features to overcome the abovementioned barriers. It is the case of Distributed Economies (DE), which have been recently highlighted as complementary to S.PSS in order to reach sustainability for all. Indeed, DE is based on a shift from centralized to decentralized/distributed systems in which a small-scale unit of production is locally based, i.e. nearby or at the point of use, and where the user can become a producer. This integrates S.PSS with a set of additional socio-ethical benefits, giving local users direct access to resources and increasing their participation in the whole system life cycle, e.g. democratizing the access to resources; adding value to resources in the region; improving the connection between producers and consumers - removing intermediaries - hence improving knowledge on sustainability; increase local information/knowledge, know-how and local people's capabilities (Vezzoli et al., 2021, 2022).

Moreover, as the next paragraph will mention, different methods and tools allow to design S.PSS for specific conditions and requirements, which would allow to go in-depth with complex situations in low-income contexts, also known as Bottom of the Pyramid.

5. Designing S.PSS applied to CE for All: approaches, skills, and a method

The introduction of PSS innovation for sustainability into design has led design researchers to work on defining new skills of a more strategic nature (Brezet et al., 2001; Manzini & Vezzoli, 2003; Tischner et al., 2009; Ceschin, 2012; Vezzoli et al., 2014), which aim at system innovation for sustainability through a convergence of stakeholder interests and are coherent with the satisfaction-based approach. 'Strategic' here also refers to the necessary acknowledgment of cultural contexts and inherent opportunities and barriers built into the social fabric.

In relation to the characteristics of S.PSS and their inherent connection with Circular Economy principles described in the previous section, three main approaches and related skills for Product-Service System Design for circularity (and Sustainability more widely) could be highlighted (adapted from Vezzoli et al., 2018)

- a **CE** "**satisfaction-system**" approach: calling for skills to design the satisfaction of a particular demand (a "satisfaction unit") and hence all its related CE products and services;

- a **CE** "**stakeholder configuration**" approach: calling for skills to design the interactions of the stakeholders of a particular CE satisfaction-system;

- a **CE** "**system sustainability**" approach: calling for skills to design such CE stakeholder interactions (CE offer model) that make the providers economically incentivized to continuously seek both techno-cycles and bio-cycles new beneficial solutions accessible to all.

The first key point lies in the so-called *satisfaction-based CE approach*, where the focus is no longer on delivering a single CE product. It is thus inadequate to merely design or assess a single CE product, instead, we consider the whole process of every product and service associated with satisfying certain needs and/or desires. This is indeed also one of the principles considered within the definition of Circular Economy itself (Ellen MacArthur Foundation, 2021). The second key issue is to introduce a *stakeholder CE configuration approach*. If we want to design the CE stakeholder interactions, the system design approach should project and promote innovative types of interactions and partnerships between appropriate socio-economic

stakeholders, while responding to a particular social demand for satisfaction. Therefore, designing the configuration of a CE system means understanding what stakeholder profiles should be in place and what the best interrelationships are, in the sense of financial, resource, information, or labour flows. Last but not least, it must be emphasized that, as stated by various authors (O. K. Mont, 2002; UNEP, 2002; Cooper, 2005; Vezzoli, 2010; Ceschin, 2012), not all PSS innovations are driven by the economic interest to promote techno-cycles or bio-cycles (more in general to have a reduced environmental impact), nor do they necessarily promote good and services accessible to all (i.e. to promote social equity and cohesion). For this reason, it is expedient to operate and adopt appropriate criteria and guidelines in the design process towards CE-oriented (more in general sustainable) stakeholder interactions/relationships. Having understood this, **Product- Service System design for Circular Economy for all (more in general sustainability for all)** can be defined as follows (adapted from Vezzoli et al., 2021):

the design of the Circular Economy system of products and services that are together able to fulfill a particular customer demand (to deliver a "unit of satisfaction"), based on the design of innovative interactions between the stakeholders of the CE value production system (CE satisfaction system), where the ownership of the CE product/s and/or the life cycle services costs/responsibilities remain with the provider/s so that the same provider/s continuously seek/s technical cycles or biological cycles eventually accessible to all, together with economic benefits.

Given that the S.PSS applied to the CE design approach moves toward the design of innovative stakeholder interactions able to respond to a particular social demand, new skills are required from the designer, directly or as a facilitator of a design process:

- A designer must be able to design both products and services with a CE approach, in relation to a given demand (needs and/or desires), i.e. a satisfaction system that fulfill a given demand of needs and/or desires, as a single satisfaction unit;

- A designer must be able to identify, promote and facilitate innovative CE configurations (i.e. interactions/partnerships based on a Circular Economy approach) between and among different stakeholders (entrepreneurs, users, NGOs, institutions, etc.).

Moreover, since S.PSS applied to CE design aims at developing innovations that have a low environmental impact throughout technical cycles and/or biological cycles, eventually accessible to, with economic benefits - it is clear that a designer must be capable to design S.PSSs applied to CE systems (and related stakeholder interactions) as win-win beneficial new solutions. Consequently, new skills are required from the designer:

- The ability to orientate the CE system design process towards *eco-efficient* solutions, encompassing both environmental and economic sustainability;

- The ability to orientate the CE system design process towards *socio-efficient* solutions encompassing both socio-ethical and economic sustainability.

Moving to a more operative dimension, it is worth mentioning that methods and tools to design S.PSS have been developed since 2005, supported by a set of research projects funded by the European Union and the

United Nations Environment Programme (UNEP), the main ones being D4S[5], SusHouse,[6] ProSecCo,[7] HiCS,[8] MEPSS,[9] SusProNet,[10] LeNS,[11] LeNSes[12] and LeNSin[13].

One of the most adopted by the international design community is the Method for System Design for Sustainability (MSDS) (Vezzoli et al., 2021). Indeed, this method and its tools consider most of the CE principles, so forth it is introduced in its main scope here.

5.1 Method for System Design for Sustainability (MSDS)

The MSDS method – adapted from (Vezzoli et al., 2021) - has been developed and refined in the course of a couple of decades with the aim of supporting the design of the Product-Service System, in order to orient the system innovation development process toward win-win solutions for sustainability, among which even the regeneration of technical cycles and the restoration of biological ones. The MSDS method is conceived for designers and companies but is also appropriate for public institutions, NGOs, and another type of organisations. It can be used by an individual designer, by a wider design team or by a multidisciplinary team facilitated by a designer. In all cases special attention has to be paid to facilitating co-designing processes both within the organization itself (between people from different disciplinary backgrounds) and outside, bringing different socio-economic actors and end-users into the design process.
The scope of the method is to support design processes for the development of S.PSS (eventually applicable to CE), and it is characterized by a flexible modular structure that makes it easily adaptable to specific design requirements, diverse design contexts, and conditions and usable in existing design procedures/practices. All the tools developed are open-access and free to download at www.lens-international.org.

Without going into a detailed description below a scheme is presented to introduce it, by highlighting its processes and related aims and support tools (related to each design stage). A detailed description can be found on www.lens-international.org and in several international publications (Vezzoli et al., 2014, 2018, 2021)

System design stages	Method for System Design for Sustainability		
	Aims	**Processes**	**Tools**
Strategic analysis	To obtain the information necessary to facilitate the generation of sustainable system innovation ideas	- Analysis of project proposers and outline of the intervention context - Analysis of the context of reference in relation to its technical and biological cycles - Analysis of the carrying structure of the system in relation to its technical and biological cycles -An Analysis of S.PSS & CE best practices	- Checklist for the analysis of the existing system and priority set (SDO toolkit) - S.PSS Innovation Diagram

[5] Design for Sustainability (D4S): A Step-By-Step Approach, UNEP funded, 2005–2009.

[6] SusHouse: Strategies towards the Sustainable Household, EU-FP4 funded, 1998–2000.

[7] ProSecCo: Product-Service Co-design, EU-FP5 funded, 2002–2004.

[8] HiCS: Highly Customerised Solutions, EU funded, 2001–2004.

[9] MEPSS: MEthodology for Product Service System development, EU- FP5 funded, 2002–2005.

[10] SusProNet: Sustainable Product-Service co-design Network, EU-FP5 funded, 2002–2005.

[11] LeNS: Learning Network on Sustainability, EU-EuropAid funded 2008–2010.

[12] LeNSes: Focused on System Design for Sustainable Energy for all, EU-Edulink funded, Oct 2013–Oct 2016.

[13] LeNSin: focused on designing S.PSS applied to DE as a promising approach for designing sustainability for all, EU-Erasmus+ funded, 2015–2019.

		- Analysis of the sustainability of the existing system and determine priorities for the design intervention in view of sustainability (for both technical and biological cycles)	
Exploring system opportunities	To make a 'catalog' of sustainability-promising and CE system possibilities	- Generation of circular and sustainability-oriented ideas - Outline a design-oriented sustainability and CE scenario	- Sustainable idea boards (SDO toolkit) – SDOScenario Polarities
System concept design	To design one or more CE system concepts oriented toward sustainability	- Select clusters and single ideas - Develop S.PSS & CE concepts - Environmental, socio-ethical, and economic qualitative check assessment	- S.PSS Innovation Diagram - S.PSS Concept description form - Checklist for the system sustainability improvement evaluation (SDO toolkit)
System detailed design (and engineering)	To develop the most sustainability-promising CE system concept into the detailed version necessary for its implementation	- Detailed sustainability and CE system design - Environmental, socio-ethical, and economic qualitative check and visualisation	- System map for S.PSS - Stakeholders motivation and sustainability table - Interaction table - Stakeholders interaction storyboard - Satisfaction offering diagram - Checklist for the system sustainability improvement evaluation (SDO toolkit) - Radar (SDO toolkit)
Communication	To draw up reports to communicate the sustainable characteristics of the designed CE system.	- Draw up the documentation for communications of sustainability	- Animatic for S.PSS

Tab. 5.1 The MSDS aims, processes, and tools, in relation with the typical Product-Service System design stages.

6. Discussion and final considerations

Sourcing from the learnings of the LeNSin project and from the ongoing research activity of the LeNS network, the chapter makes a step forward, following the hypothesis that the theory and practice of S.PSS design can be valuable to develop Circular Economy systems accessible to all – even to low-income contexts and communities. Based on this premise and from the key concepts of CE, the chapter considers the existing literature on circular business models and S.PSS & CE. Besides multiple synergies in terms of knowledge base and principles and a growing empirical research context, there are still debates regarding the solid integration and design of the two models. Secondly, the chapter recognizes the paucity of research that amalgamates S.PSS with CE models to foster socio-economic inclusivity, especially in low- and middle-income contexts.
All this considered, an unexplored convergence between the two models is identified. Key findings in this sense are S.PSS win-win benefits applied to CE, highlighting different configurations in which the economic interest on a system level is proportional to environmental and socio-ethical benefits. So forth, S.PSS design capabilities are depicted as potentially fundamental to bringing circular business models into practice, making organization and designers able to manage specific methods and tools (e.g. the MSDS method).

In this sense, the chapter represents a contribution to the theoretical and practical knowledge base on both S.PSS and Circular Economy, transcending the mere alignment of concepts and focusing on how the former could become an enabler, even from a socio-ethical point of view.

Even though a general framework has been here outlined, indeed, this research hypothesis needs to be further investigated. As described in the text, it seems to be quite promising, but a further and articulated research action plan needs to be taken, to advance the knowledge-base and know-how up to a level where it can become an effective leverage for sustainable change. For example, an extended variety of S.PSS sub-types and specifications could be analyzed from a system perspective as an enabler of Circular Economy.
Although this contribution took into analysis the three main S.PSS typologies (product-oriented, use-oriented, and result-oriented), many specifications exist and have been evolving over the years, both in the literature and in the industry, e.g. product pooling, product-related services, pay-per-service unit.

Furthermore, also MSDS method and its tools would also benefit from dedicated research activities to make it more specific and so forth more effective in supporting designer in S.PSS design when the issue is that of designing and implementing CE adopting an S.PSS offer model. This is even more evident and open to be developed when we want to generate and consolidate the new knowledge to design CE systems accessible and preservable over time even in low- and middle-income contexts. To give a concrete contribution to the diffusion of the design and implementation of CE systems accessible to all.

7. Bibliography

Arora, S., & Romijn, H. (2011). The empty rhetoric of poverty reduction at the base of the pyramid. *Organization*. 19(4),481–505. https://doi.org/10.1177%2F1350508411414294

Baines, T. S., Lightfoot, H. W., Evans, S., Neely, A., Greenough, R., Peppard, J., Roy, R., Shehab, E., Braganza, A., Tiwari, A., Alcock, J. R., Angus, J. P., Bastl, M., Cousens, A., Irving, P., Johnson, M., Kingston, J., Lockett, H., Martinez, V., … Wilson, H. (2007). State-of-the-art in product-service systems. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, *221*(10), 1543–1552. https://doi.org/10.1243/09544054JEM858

Bocken, N. M. P., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, *33*(5), 308–320. https://doi.org/10.1080/21681015.2016.1172124

Bressanelli, G., Perona, M., & Saccani, N. (2017). Reshaping the Washing Machine Industry through Circular Economy and Product-Service System Business Models. *Procedia CIRP*, *64*, 43–48. https://doi.org/10.1016/j.procir.2017.03.065

Brezet, J., Bijma, A. S., Ehrenfeld, J., & Silvester, S. (2001). *The design of eco-efficient services: Method, tools and review of the case study based «designing eco-efficient services» project*. Industrieel Ontwerpen.

Ceschin, F. (2012). *The introduction and scaling up of sustainable Product-Service Systems. A new role for strategic design for sustainability* [Doctoral dissertation, Politecnico di Milano]. https://www.politesi.polimi.it/handle/10589/56785

Ceschin, F., & Gaziulusoy, I. (2016). Evolution of design for sustainability: From product design to design for system innovations and transitions. *Design Studies*, *47*, 118–163. https://doi.org/10.1016/j.destud.2016.09.002

Ceschin, F., & Gaziulusoy, İ. (2019). *Design for Sustainability: A Multi-level Framework from Products to Socio-technical Systems*. Routledge. https://doi.org/10.4324/9780429456510

Charter, M., & Tischner, U. (2017). *Sustainable Solutions: Developing Products and Services for the Future*. Routledge.

Cooper, T. (2005). *Methodology for Product-Service System Innovation. How to Develop Clean, Clever and Competitive Strategies in Companies*.

Cooper, T., & Evans, S. (2000). *Products to services, London: Friends of the Earth.*

Dembek, K., York, J., & Singh, P. J. (2018). Creating value for multiple stakeholders: Sustainable business models at the Base of the Pyramid. *Journal of Cleaner Production, 196*, 1600–1612. https://doi.org/10.1016/j.jclepro.2018.06.046

Ellen MacArthur Foundation. (2013). *Towards the Circular Economy Vol. 1: An economic and business rationale for an accelerated transition | Shared by Business*. ellenmacarthurfoundation.org. https://emf.thirdlight.com/link/x8ay372a3r11-k6775n/@/preview/1?o

Ellen MacArthur Foundation. (2021). *What is the circular economy?* ellenmacarthurfoundation.org. https://archive.ellenmacarthurfoundation.org/circular-economy/what-is-the-circular-economy

European Commission. (2020). *Circular economy action plan: For a cleaner and more competitive Europe*. Publications Office of the European Union. https://data.europa.eu/doi/10.2779/05068

Geissdoerfer, M., Morioka, S. N., de Carvalho, M. M., & Evans, S. (2018). Business models and supply chains for the circular economy. *Journal of Cleaner Production*, *190*, 712–721. https://doi.org/10.1016/j.jclepro.2018.04.159

Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production*, *143*, 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048

Ghafoor, S., Hosseini, M. R., Kocaturk, T., Weiss, M., & Barnett, M. (2023). The product-service system approach for housing in a circular economy: An integrative literature review. *Journal of Cleaner Production*, *403*, 136845. https://doi.org/10.1016/j.jclepro.2023.136845

Hernandez, R. J. (2019). Sustainable Product-Service Systems and Circular Economies. *Sustainability*, *11*(19), Article 19. https://doi.org/10.3390/su11195383

Hobson, K., Lynch, N., Lilley, D., & Smalley, G. (2018). Systems of practice and the Circular Economy: Transforming mobile phone product service systems. *Environmental Innovation and Societal Transitions*, *26*, 147–157. https://doi.org/10.1016/j.eist.2017.04.002

Hockerts, K., & Weaver, N. (2002, maggio 9). *Towards a theory of sustainable product service systems – what are the dependent and independent variables of spss?*

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, *127*, 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005

Kjaer, L. L., Pigosso, D. C. A., Niero, M., Bech, N. M., & McAloone, T. C. (2019). Product/Service-Systems for a Circular Economy: The Route to Decoupling Economic Growth from Resource Consumption? *Journal of Industrial Ecology*, *23*(1), 22–35. https://doi.org/10.1111/jiec.12747

Korhonen, J., Honkasalo, A., & Seppälä, J. (2018). Circular Economy: The Concept and its Limitations. *Ecological Economics*, *143*, 37–46. https://doi.org/10.1016/j.ecolecon.2017.06.041

Manzini, E., & Vezzoli, C. (2003). A strategic design approach to develop sustainable product service systems: Examples taken from the 'environmentally friendly innovation' Italian prize. *Product Service Systems and Sustainable Consumption*, *11*(8), 851–857. https://doi.org/10.1016/S0959-6526(02)00153-1

Mont, O. (2004). Institutionalisation of sustainable consumption patterns based on shared use. *Ecological Economics*, *50*(1), 135–153. https://doi.org/10.1016/j.ecolecon.2004.03.030

Mont, O. (2002). Clarifying the concept of product–service system. *Journal of Cleaner Production*, *10*(3), 237–245. https://doi.org/10.1016/S0959-6526(01)00039-7

Nakata, C., & Weidner, K. (2012). Enhancing New Product Adoption at the Base of the Pyramid: A Contextualized Model. *Journal of Product Innovation Management, 29*(1), 21–32. https://doi.org/10.1111/j.1540-5885.2011.00876.x

Nußholz, J. L. K. (2017). Circular Business Models: Defining a Concept and Framing an Emerging Research Field. *Sustainability*, *9*(10), 1810. https://doi.org/10.3390/su9101810

Padilla-Rivera, A., Russo-Garrido, S., & Merveille, N. (2020). Addressing the Social Aspects of a Circular Economy: A Systematic Literature Review. *Sustainability*, *12*(19), 7912. https://doi.org/10.3390/su12197912

Piesik, S., Annukka, B., Antikainen, R., Ernesto, H., Kauppi, S., Kautto, P., Lazarevic, D., & Saikku, L. (2018). *Circular Economy for Sustainable Development*. Finnish Environment Institute.

P. P. Pieroni, M., C. McAloone, T., & C. A. Pigosso, D. (2019). Configuring New Business Models for Circular Economy through Product–Service Systems. *Sustainability*, *11*(13), Article 13. https://doi.org/10.3390/su11133727

Social Circular Economy. (2018). *Social Circular Economy: Opportunities for People, Planet and Profit*. socialcirculareconomy.com. https://circulareconomy.europa.eu/platform/en/knowledge/social-circular-economy-opportunities-people-planet-and-profit

Stahel, W. R. (2019). *The Circular Industrial Economy in a Nutshell*. Designing Sustainability for All - 3rd LeNS World Distributed Conference Proceedings, Milano, IT.

Stahel, W. R., & MacArthur, E. (2019). *The Circular Economy: A User's Guide*. Routledge. https://doi.org/10.4324/9780429259203

Tischner, U., Vezzoli, C., & Ryan, C. (2009). Product-Service Systems. In *Design for Sustainability: A Step-by-Step Approach*. https://www.academia.edu/25700047/Design_for_Sustainability_A_Step_by_Step_Approach

Tukker, A. (2004). Eight types of product–service system: Eight ways to sustainability? Experiences from SusProNet. *Business Strategy and the Environment*, *13*(4), 246–260. https://doi.org/10.1002/bse.414

Tukker, A. (2015). Product services for a resource-efficient and circular economy – a review. *Journal of Cleaner Production*, *97*, 76–91. https://doi.org/10.1016/j.jclepro.2013.11.049

UNEP. (2002). *Product-service systems and sustainability: Opportunities for sustainable solutions*. UNEP. https://wedocs.unep.org/xmlui/handle/20.500.11822/8123

Vezzoli, C. (2010). *System design for sustainability: A promising approach for low- and middle-income contexts*. International forum Design for Sustainability in Emerging Economies, Mexico City.

Vezzoli, C., Ceschin, F., Osanjo, L., M'Rithaa, M. K., Moalosi, R., Nakazibwe, V., & Diehl, J. C. (2018). *Designing Sustainable Energy for All: Sustainable Product-Service System Design Applied to Distributed Renewable Energy*. Springer International Publishing. https://doi.org/10.1007/978-3-319-70223-0

Vezzoli, C., Garcia, B., & Kohtala, C. (A c. Di). (2021). *Designing Sustainability for All: The Design of Sustainable Product-Service Systems Applied to Distributed Economies*. Springer International Publishing. https://doi.org/10.1007/978-3-030-66300-1

Vezzoli, C., Kohtala, C., Srinivasan, A., Diehl, J. C., Fusakul, S., Liu, X., & Sateesh, D. (2014). *Product-Service System Design for Sustainability*.

Vezzoli, C., Macrì, L., & Yang, D. (2022). *System design for sustainability in practice.* Maggioli. https://www.maggiolieditore.it/system-design-for-sustainability-in-practice.html