Product-Service Systems Development for Sustainability. A New Understanding

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1 The Role of PSS in Addressing Sustainability

1.1 The Sustainability Challenge

In 1972 the book *Limits to Growth* was published based on a first computerized simulation of the effects on nature of the ongoing system of production and consumption [19]. It was the first scientific forecast of a possible global eco-system collapse. Fifteen years later, in 1987, the United Nations (UN) World Commission for Environment and Development (WCED) provided the first definition of Sustainable Development: A social and productive development that takes place within the limits set by "nature" and meets the needs of the present without compromising those of the future generation within a worldwide equitable redistribution of resources. This also incorporates the fundamental challenge of social equity and cohesion (i.e. the socio-ethical dimension of sustainability). In the autumn of 2015, the UN updated the commitments, goals and actions for sustainable development by approving the "Agenda 2030 for Sustainable Development" [28] as a mutual commitment to global development, in favour of human well-being and to preserve the environment. The main outputs of the Agenda are the 17 Sustainable Development Goals (SDGs), which gather together the main challenges to be achieved by 2030 in relation to the three dimensions of sustainable development, i.e. the environmental protection, the social inclusion and the economic prosperity.

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It is within this framework that this book presents Sustainable Product-Service System (S.PSS) and Distributed Economies (DE) as key promising and interwoven offer models coupling environmental and social with economic sustainability. Moreover, S.PSS applied to DE is a promising approach to diffuse sustainability in low- and middle-income contexts. This volume also elaborates on the role design can play to generate new ideas and solutions addressing S.PSS applied to DE, as well as develop and diffuse related solutions, i.e. designing sustainability for all. This chapter presents an updated understanding of how PSS addresses Sustainability and the role of design.

1.2 Sustainable Product-Service System: A Win-Win Opportunity for Sustainability

A key contemporary query is the following: within the entangled and complex environmental, social and economic crises, where are the opportunities? Do we know any offer or 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? In fact, the concept of Sustainable Product-Service System (S.PSS) has been studied since the end of the 1990s [10, 12, 18, 20, 23, 29] as a promising offer/business model in this regard. More recently, S.PSS has been demonstrated [32, 36] to be a clearly promising offer model to extend the access to good 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 with the environmental and the socio-ethical. An S.PSS can be defined as follows [36]:

> Sustainable Product-Service System (S.PSS) is an offer model providing an integrated mix of products and services that are together able to fulfil 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):

- They shift the business focus from selling (only) **products** to offering a so-called "**unit of satisfaction**",[1] i.e. a combination of products and services jointly capable of achieving an 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.

This approach is also supported by the European Union in its action plan on the Circular Economy, when stating that: "incentivising product-as-a-service or other models where producers keep the ownership of the product or the responsibility for its performance throughout its lifecycle" [10]. 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.

1.3 PSS Types

Three main S.PSS approaches to system innovation have been studied and listed as favourable for eco-efficiency [13, 26, 29, 37]:

1. *Product-oriented S.PSS*: services providing added value to the product life cycle.
2. *Use-oriented S.PSS*: services providing "enabling platforms" for customers.
3. *Result-oriented S.PSS*: services providing "final results" for customers.

Product-oriented S.PSS: adding value to the product life cycle (type I)

Let us start with an example of an eco-efficient system innovation adding value to the product life cycle.

Fig. 1 S.PSS: a paradigm shift from a traditional product offer

[1] A satisfaction unit can be defined as [36] "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".

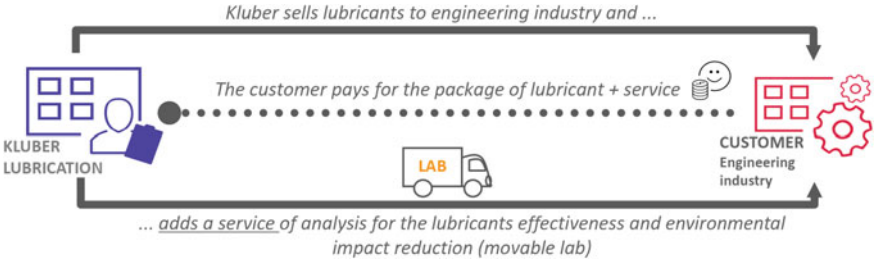

Fig. 2 Klüber lubricants service. Main company-customer interactions

Klüber lubricants service
Klüber offers lubricants plus the service for on-site identification of equipment inefficiency, and the potential reduction of emissions' impact (see Fig. 2). This innovative interaction between the company and the customer adding all-inclusive life cycle services allows the company's economic interest to be different from only selling more lubricants.

In summary, a ***Product-oriented S.PSS*** *innovation* adding value to the product life cycle is defined as:

> a company/organization (alliance of companies/organizations) that provides all-inclusive life cycle services – maintenance, repair, upgrading, substitution and product take-back – to guarantee the life cycle performance of the product/semi-finished product (sold to the customer/user).

A typical service contract would include maintenance, repair, upgrading, substitution and product take-back services 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 environmentally beneficial new solutions, i.e. the economic interest becomes something other than only selling a larger amount of products.

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

The following box describes an example of an eco-efficient system innovation as enabling platforms for customers.

Riversimple. Pay-per-month mobility solution
Riversimple provides a pay-per-month ownerless car with all-inclusive energy, maintenance, repair, insurance and end-of-life collection (see Fig. 3). This

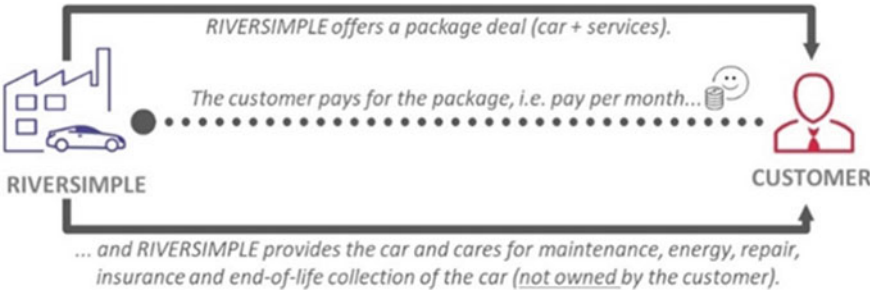

Fig. 3 Riversimple. Pay-per-month mobility solution

type of innovative interaction between the company and the customer (owner-less car with all-inclusive life cycle services) promotes the provider's economic interest to foster the design or offer of a long-lasting, energy-efficient and recyclable car.

In summary, a ***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 leasing, pooling or sharing 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 environmentally beneficial new solutions together with economic benefits, e.g. to design highly efficient, long-lasting, reusable and recyclable products.

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

The following describes an example of an eco-efficient system innovation providing final results to customers.

Philips. Pay-per-Lux
The customer pays to have an agreed amount of lighting (lux) in its building. Philips is responsible for (paying for) the installation, upgrading, repair and

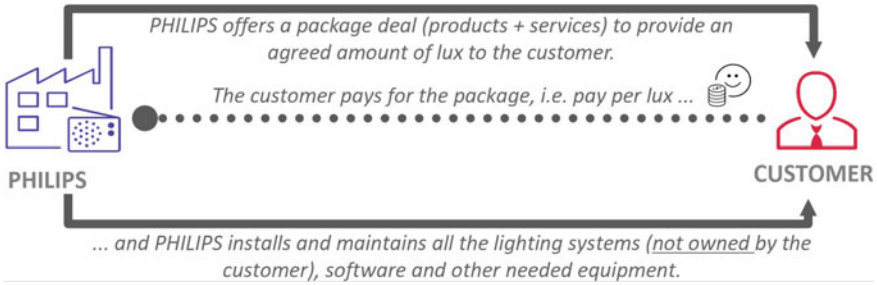

Fig. 4 Philips. Pay-per-Lux

end-of-life collection of all products/equipment (owned by Philips) (Fig. 4). This kind of innovative interaction between the company and the customer (an ownerless lighting system with all-inclusive life cycle services) encourages the provider's economic interest to foster the design/offer of long-lasting, reusable and recyclable lighting systems.

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

> 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 environmentally beneficial new solutions, e.g. long-lasting, reusable and recyclable products. Moreover, if properly conceived, S.PSS can offer to low- and middle-income people the possibility to have access to services that traditional product sales models would not allow (i.e. by lower initial costs).

In fact, it has been argued that in low- and middle-income contexts "an S.PSS innovation may act as a business opportunity to facilitate the process of socio-economic development by jumping over the stage characterized by individual consumption/ownership of mass-produced goods towards a 'satisfaction-based' and 'low resource-intensity' advanced service-economy" [29].

1.4 S.PSS Environmental Benefits

When is an S.PSS eco-efficient? Better still, when is an S.PSS decoupling the economic interests from both an increase in resource consumption and a decrease of demaging environmental impacts?

In other words, why and when is an S.PSS producer/provider economically interested in design for environmental sustainability? The following S.PSS environmental and economic win-win benefits could be highlighted (adapted from [36]):

(a) *Product lifetime 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 the product with its maintenance, repair, upgrade and substitution, the **longer** the product/s or its components 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 lifespan extension of product/s (with eco-efficient product Life Cycle Design (LCD) implications) (Fig. 5).

(b) *Intensive use of product*: As far as the S.PSS provider is selling a shared 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 (environmental benefits), the **higher** the profit, i.e. proportionally to the overall use time (economic benefits). Hence, the producer/providers are driven by economic interests to design for intensive use of product/s (eco-efficient product LCD implications) (Fig. 6).

(c) *Resource consumption minimization*: As far as the S.PSS provider is selling all-inclusive the access to products and the resources it consumes in use, with payment based on unit of satisfaction (product's ownership by the producer/provider), the **higher** the product/s resource efficiency in use is (environmental benefits), and the **higher** the profit, i.e. the payment minus (among others) the costs of resources in use (economic benefits). Hence, the producer/provider is driven by economic interests to design/offer product/s minimizing resource consumption in use (eco-efficient product LCD implications) (Fig. 7).[3]

(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** 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) for

[2] Even marketing and advertisement costs could be avoided.

[3] Resource efficiency might include the end-of-life stage (recycling, re-use, composting, etc.) where it would be of interest to the S.PSS provider to make this stage also economically relevant.

passive/renewable resource optimization (eco-efficient product LCD implications) (Fig. 8).

(e) *Material life 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 recycled, incinerated with energy recovery or composted (environmental benefits), the **more** costs are avoided of both landfilling and either the purchase of new primary material, energy or compost (economic benefits). Hence, the producer/provider is driven by economic interests to design for material life extension, i.e. recycling, energy recovery or composting (eco-efficient product LCD implications) (Fig. 9).

(f) *Minimization of toxicity and harmfulness*: As far as the S.PSS provider is selling toxic or harmful product/s all-inclusive with use and/or end-of-life toxicity/harm management services, the **lower** the potential toxic or harmful emissions are in use and/or at the end-of-life (environmental benefits), the **more** costs are avoided of both toxic/harmful treatments in use and/or at the end-of-life. Hence, the producer/provider is driven by economic interests to design (offer) for toxicity/harm minimization (eco-efficient product LCD implications) (Fig. 10).

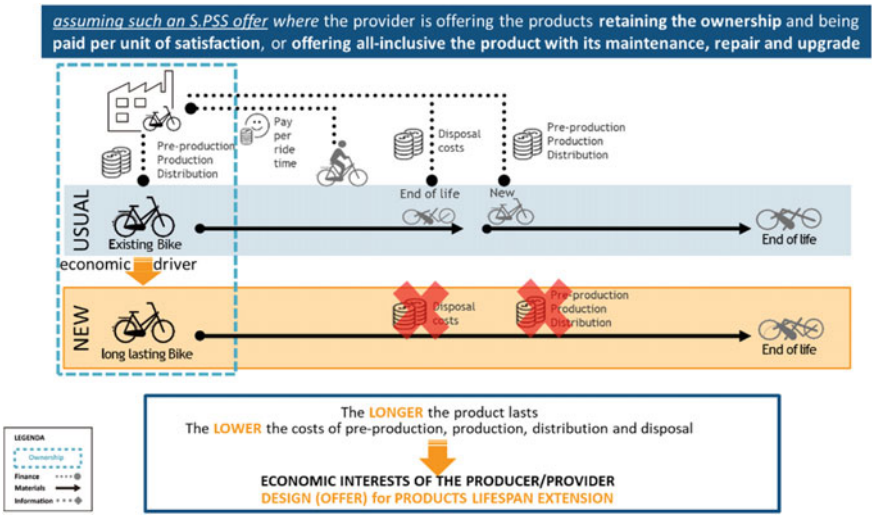

Fig. 5 S.PSS model fostering the design (offer) for product lifespan extension

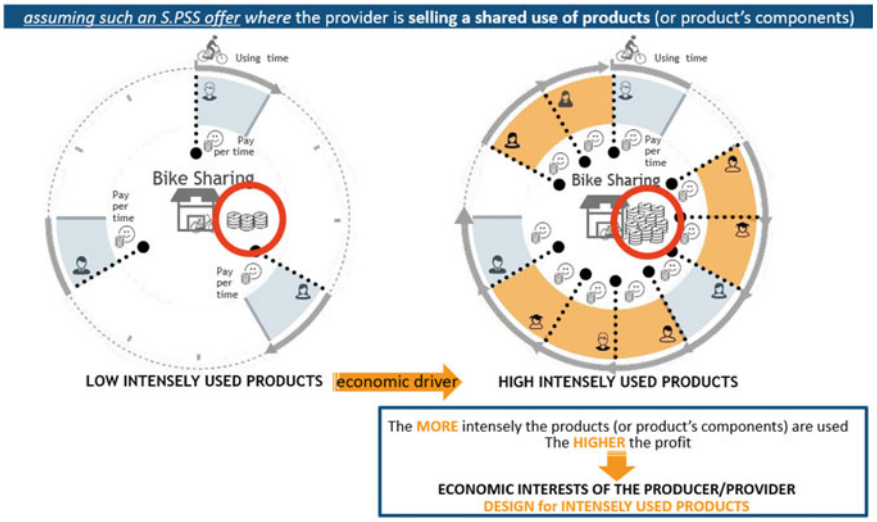

Fig. 6 S.PSS model fostering the design (offer) for intensive use of the product

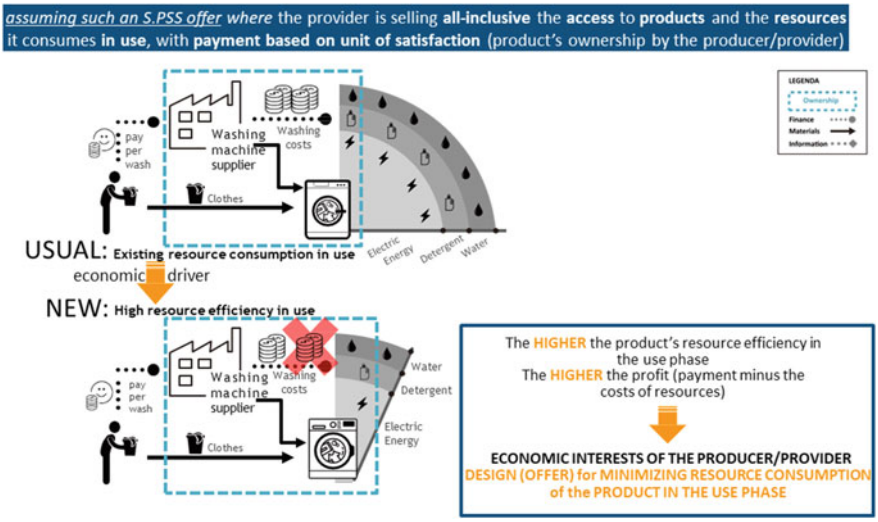

Fig. 7 S.PSS model fostering the design (offer) of products minimizing resource consumption in the use phase

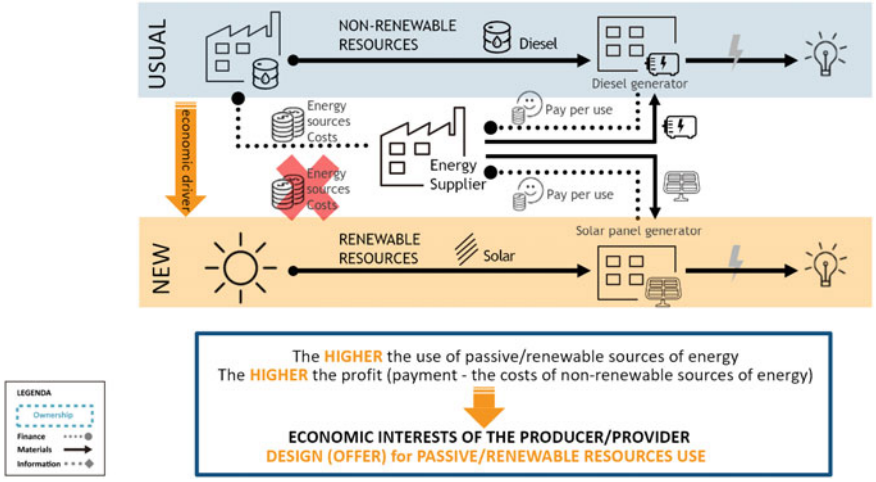

Fig. 8 S.PSS model fostering the design (offer) for passive/renewable resource optimization

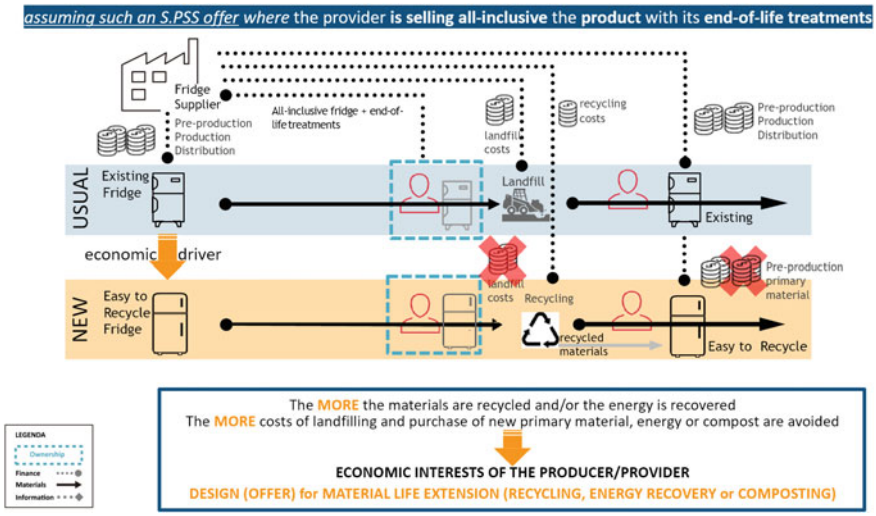

Fig. 9 S.PSS model fostering the design (offer) for material life extension (recycling, energy recovery or composting)

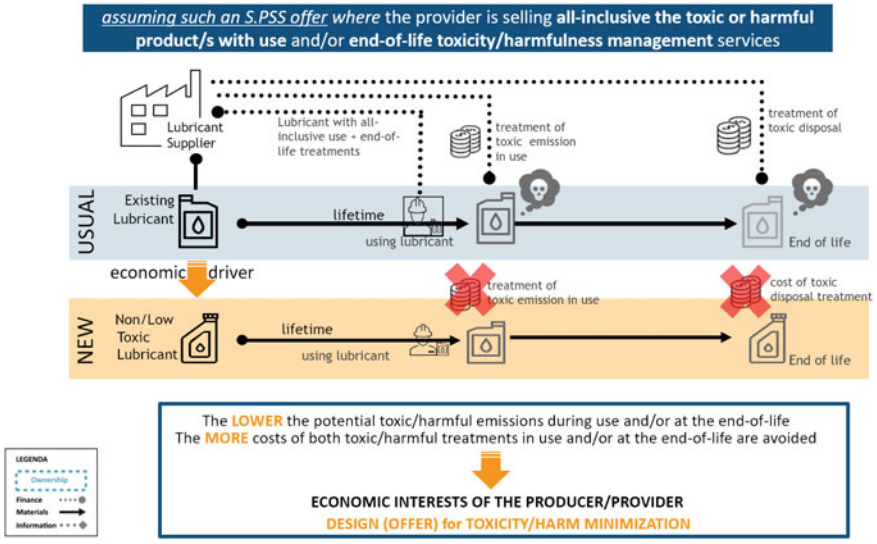

Fig. 10 S.PSS model fostering the design (offer) for toxicity/harm minimization

Fig. 11 S.PSS as a model making product Life Cycle Design economically relevant for the manufacturer/provider

To conclude, when is an S.PSS eco-efficient? 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 LCD/eco-design approach is economically beneficial (Fig. 11).

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

- product lifespan extension and use intensification;
- material life extension (recycling, energy recovery, composting);
- material consumption minimizations;
- energy consumption minimizations;
- resources' (materials and energy) renewability/biocompatibility;
- resources' (materials and energy) toxicity/harmfulness minimization.

1.5 S.PSS Socio-Ethical Benefits

Why may S.PSS foster socio-ethical benefits? Because S.PSS make goods and services economically accessible to both final users and entrepreneurs, also in low- and middle-income contexts. The following S.PSS socio-ethical and economic win-win benefits could be highlighted (updated from [36]): 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 the S.PSS model is 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. 12).

(b) *Reduction of interrupted product use*: As far as the S.PSS model is selling the 'unit of satisfaction' including life cycle services costs, this reduces or avoids running costs for maintenance, repair, upgrade, etc. 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. 13).

(c) *Enterpreneurs/organizations' equipment accessibility*: As far as the S.PSS model is 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. 14).

(d) *Reduction of interrupted equipment use*: As far as the S.PSS model is selling all-inclusive life cycle services with the equipment offer to entrepreneurs,

this reduces or avoids running costs for equipment maintenance, repair, upgrade, 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. 15).

(e) *Local employment and competencies improvement*: As far as the S.PSS model is offering goods and services without product purchasing costs, they open new

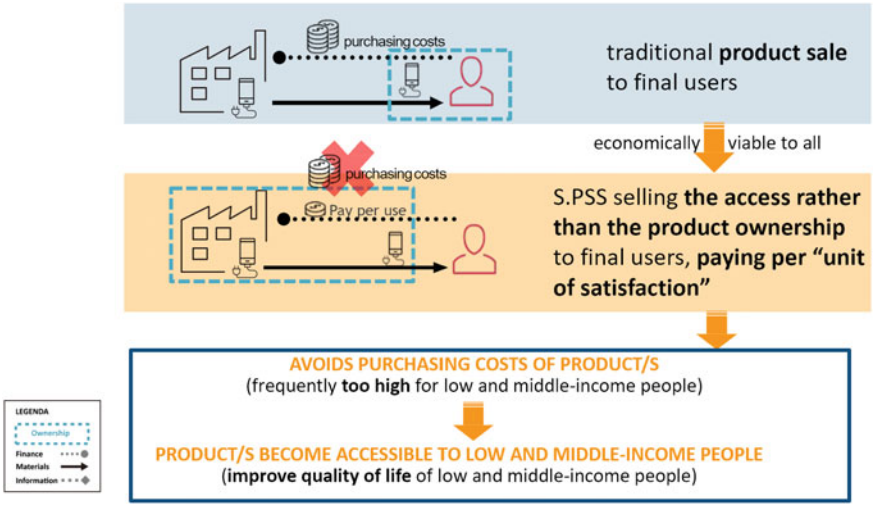

Fig. 12 S.PSS model making product/s accessible to low- and middle-income end-users

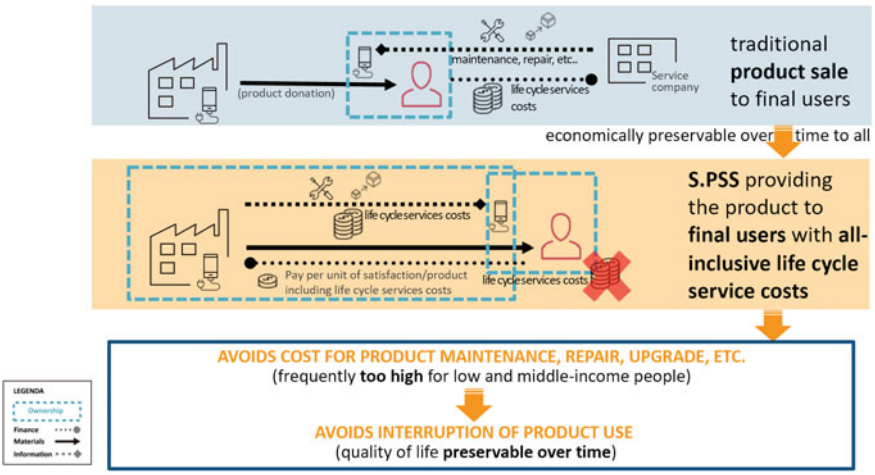

Fig. 13 S.PSS model making quality of life preservable over time in low- and middle-income contexts

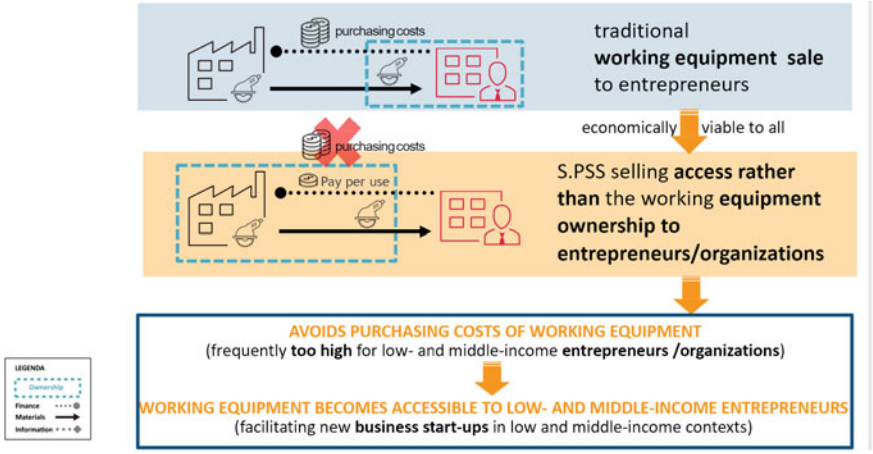

Fig. 14 S.PSS model facilitating new business start-ups in low- and middle-income contexts

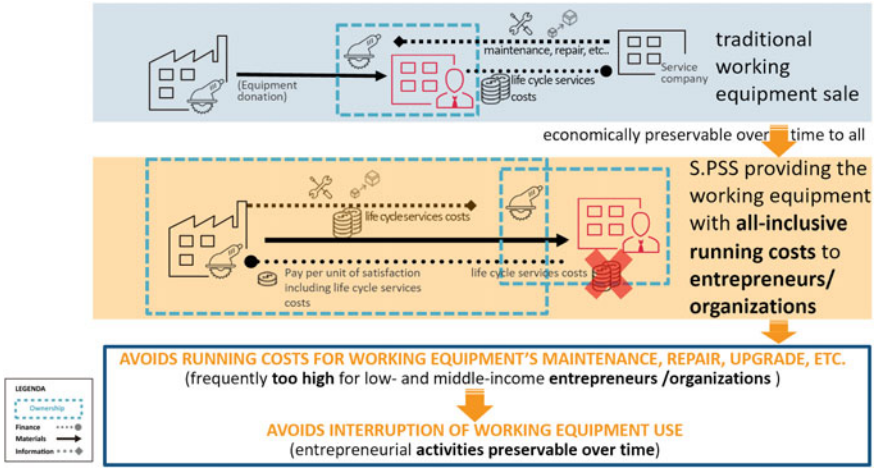

Fig. 15 S.PSS model making entrepreneurial activities preservable over time

market opportunities for local entrepreneurs via new potential low- and middle-income customers (such as Bottom of the Pyramid, or BoP), i.e. potentially empowering locally based economies and life quality (socio-ethical benefits) (Fig. 16).

The service dimension of an S.PSS demands local providers, thus generating local jobs. This contributes directly to social cohesion, as it reduces the need for migration or long commutes; increases the likelihood of better balance between work and social life; and thus provides a context where the social fabric can be built up and/or consolidated.

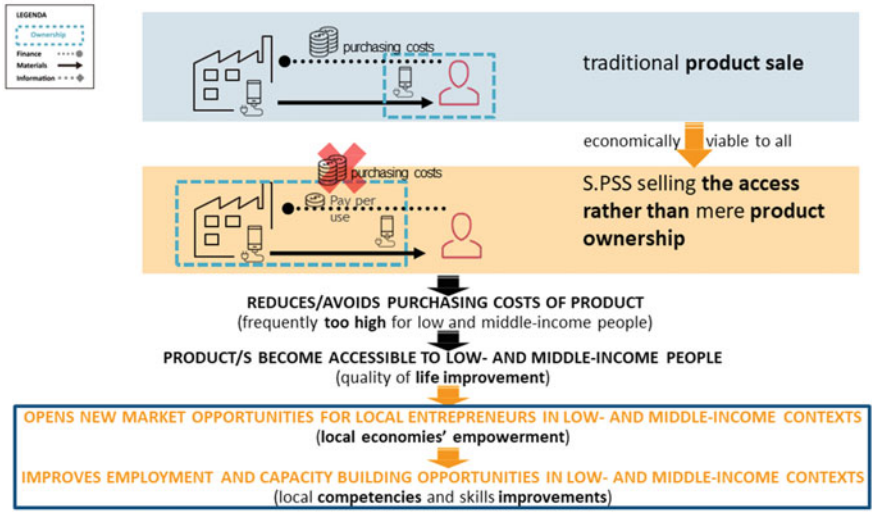

Fig. 16 S.PSS model improving local employment, competencies and skills

Fig. 17 S.PSS model improving local life quality, competencies and skills

Finally, within an S.PSS model the producer/provider is economically interested in design for social equity, i.e. to extend sustainable access to products/equipment for low- and middle-income people (see Fig. 17), 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.

1.6 S.PSS Economic and Competitive Benefits

What are the main economic and competitive benefits of S.PSS? The following S.PSS economic and competitive benefits could be highlighted [36]:

- As far as the S.PSS model offers service along all its life cycle, organizations can establish longer and stronger relationships with customers, i.e. increasing customer loyalty;
- As far as the S.PSS models are different offers from traditional product sales, which are nowadays in saturated markets, they can open up new business opportunities, i.e. empowering strategic positioning;
- As far as the S.PSS model offers goods and services without initial investment costs, they open new market opportunities for middle- and low-income people (BoP), i.e. empowering locally based economies.

2 PSS Design for Sustainability

The introduction of PSS innovation for sustainability into design has led design researchers to work on defining new skills of a more strategic nature [2, 3, 18, 25, 37], which aim at system sustainability through a convergence of stakeholder interests and are coherent with the satisfaction-based approach. 'Strategic' here also refers to the necessary acknowledgement of cultural contexts and inherent opportunities and barriers built into the social fabric.

In relation to the characteristics of S.PSS described in the previous section, three main approaches and related skills for Product-Service System Design for Sustainability could be highlighted [36]:

- a "**satisfaction-system**" approach: calling for skills to design the satisfaction of a particular demand (a "satisfaction unit") and hence all its related products and services;
- a "**stakeholder configuration**" approach: calling for skills to design the interactions of the stakeholders of a particular satisfaction-system;
- a "**system sustainability**" approach: calling for skills to design such stakeholder interactions (offer model) that make the providers economically interested to continuously seek both environmentally and socio-ethical new beneficial solutions.

The first key point lies in the satisfaction-based approach, where the focus is no longer on delivering a single product. It is thus inadequate to merely design or assess a single product, but instead we consider the whole process of every product and service associated with satisfying certain needs and/or desires. The second key task is to introduce a stakeholder configuration approach. If we want to design the 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 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 [3, 20, 29–31], not all PSS innovations are driven by the economic interest to have a reduced environmental impact, nor do they necessarily promote social equity and cohesion. For this reason, it is expedient to operate and adopt appropriate criteria and guidelines in the design process towards sustainable stakeholder interactions/relationships. Having understood this, **Product-Service System design for sustainability** can be defined as follows (adapted from [36]):

> the design of the system of products and services that are together able to fulfil a particular customer demand (to deliver a "unit of satisfaction"), based on the design of 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, together with economic benefits.

3 S.PSS in Relation to Other Design for Sustainability Approaches

This book focuses on S.PSS and the role it can play in fostering Distributed Economies. However, it remains essential to discuss the linkages between S.PSS and other Design-for-Sustainability (DfS) approaches. In fact, in order to exploit the sustainability potential of PSS solutions, other DfS approaches should be adopted and used in combination with S.PSS design [7].

To begin with, it is important to highlight that the sustainability profile of a PSS strictly depends on how the products included in the offer have been designed. It is true that through an S.PSS approach it is possible to develop business models in which the manufacturer and the other stakeholders involved in the solution have a potential economic incentive to take responsibility for the PSS life cycle and optimize material and energy consumption (see Sect. 1.4). However, in order to exploit this sustainability potential, the products need to be correctly designed. For example, in a use-oriented PSS (see Sect. 1.3), in which manufacturers keep ownership of products and offer access to them, products need to be designed to be long-lasting (considering also the shared use), easy to maintain and repair. At the same time, products should be designed to be remanufactured and ultimately to be recycled at the end of their life cycle. Thus, S.PSS design requires the integration of **product eco-design** (or **Life Cycle Design**), which focuses on reducing the environmental impact of a product looking at its different life cycle stages, from the extraction of raw materials, through manufacturing, distribution and use, and on to final disposal [24, 33, 38].

Looking more at the user-related aspects, it should be mentioned that some S.PSSs require a certain degree of change in patterns of consumption and user habits. Typically, this involves a shift from consumption based on ownership to consumption

based on access and sharing goods. Even if we are generally used to not owning and sharing certain products (for example, of the products linked to mobility services like a car or bicycle), for some product categories (e.g. appliances) there are still substantial barriers for the adoption of S.PSS-oriented offers [35]. For this reason, it becomes crucial to design S.PSS offers able to stimulate changes in user behaviour and thus support the adoption of these kinds of solutions. **Design for sustainable behaviour** (e.g. see [15, 16]), and its ability to shape and influence human behaviour to support the adoption of sustainable innovations and habits, can thus play an important role in fostering the diffusion of S.PSSs. Design for sustainable behaviour can be applied to both the product and service elements of an S.PSS (e.g. services should be designed in a way that "sharing" should be seen positively throughout the user experience).

Emotionally durable design (e.g. see [8, 21]) can also be used to support S.PSSs. Emotionally durable design focuses on enhancing and strengthening the emotional tie between the user and the product so that the user–product relationship remains satisfactory over time. In those S.PSSs in which users have individual and long-term access to a product (e.g. product-lease) it might be beneficial to create a strong emotional connection between the user and the product, and thus adopt emotionally durable design strategies.

It is also important to note the potential linkages between S.PSS and social innovations. We must acknowledge that PSS design can take inspiration from social innovations to develop new product-service offerings (e.g. commercial vegetable box subscription services that mimic similar solutions developed at a local level by communities and farmers) [7]. Thus, **design for social innovation** (defined as "a constellation of design initiatives geared toward making social innovation more probable, effective, long-lasting, and apt to spread" [17]) can enable designers to gather inspirations from community-based solutions to ideate and develop S.PSSs. On the other hand, an S.PSS design can be used as an approach to foster social innovation by triggering, sustaining and/or guiding the direction of action. Finally, we need to highlight that S.PSS innovation can be complex to implement and bring to the mainstream, as they are hindered by a range of barriers [5, 20, 27, 35]: cultural barriers (e.g. the cultural shift necessary to value ownerless offers as opposed to owning products), corporate barriers (e.g. the need to implement changes in the business mindset and strategy) and regulative barriers (e.g. lack of internalization of the environmental and social costs in market prices). **Design for sustainability transitions**, which focuses on the transformation of socio-technical systems through technological, social, organizational and institutional innovations [7], can be used to support a successful implementation of S.PSSs. In particular, it can be adopted to understand the process of the introduction and diffusion of S.PSSs and how it can be more effectively designed, managed and oriented (e.g. see [3–5, 14, 34]).

At this point, it is also useful to discuss the relationship between S.PSS and the concept of the **circular economy**. The Ellen MacArthur Foundation [9] defined circular economy as "an industrial economy that is restorative or regenerative by intention and design". Its key principles are the creation of closed-loop systems of material flows and the 3R concept (reduction, reuse and recycling of resources)

[11]. As noted by Ceschin and Gaziulusoy [6, 7], even if the concept of the 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).

S.PSS design is crucial to support a circular economy; it can lead to business models that enable and foster circularity. As noted by Ceschin and Gaziulusoy [7], with the popularization of the circular economy concept, the term circular business model (e.g. see [22]) has gradually emerged. Bocken, Pauw, Bakker and van der Grinten [1] have proposed six circular business model strategies, grouped into two main categories:

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

Apart from the different terminology and classification, the concept of S.PSS overlaps with the concept of circular business models. However, the circular business models include additional broader aspects, such as extending resource value (e.g. collection of otherwise 'wasted' materials/resources and turning them into new forms of value; [1]) and industrial symbiosis. Circular business models have a strong focus on the economic and environmental dimension of sustainability and less on the socio-economic dimension. In any case, it is clear how the concept of S.PSS represents a fundamental component of any circular economy. In fact, as stated in the recently published "EU Circular Economy Action Plan" [10], moving towards "product-as-a-service or other models where producers keep the ownership of the product or the responsibility for its performance throughout its lifecycle" is considered a key principle for sustainability, and a necessary condition to incentivize the design of sustainable products.

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