New Design Challenges to Widely Implement 'Sustainable Product-Service Systems'

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Abstract

Sustainable Product-Service Systems (S.PSS) carry great potential to deliver social well-being and economic prosperity while operating within the limits of our planet. They can however be complex to design, test, implement and bring to the mainstream. To increase our understanding of the potential benefits, drivers and barriers in S.PSS design, the research community has been inspired to collect and analyse an extensive number of cases in diverse sectors and to develop and test several design methods and tools. This Special Volume on "New Design Challenges to Widely Implement 'Sustainable Product-Service Systems'" presents results of key studies in the following areas: user satisfaction and acceptance of S.PSS solutions, how industrial partnerships and stakeholder interactions can be designed for environmental and socio-ethical benefits, how knowledge of socio-technical change and transition management feeds S.PSS design processes, and the role of policy instruments to foster their implementation and scale-up. This Introduction reviews the current state of research and summarises the articles presented. The articles demonstrate increasing confidence in integrating approaches and theoretical frameworks from other arenas. These approaches include sociological practice theory, to shed new light on consumer practices in PSS configurations, and strategic niche management, to foster a suitable design and experimentation milieu. Experimentation, iteration and cyclical design processes were also seen by many authors as crucial to implementing and stabilising S.PSS solutions, but also their continuous sustainability evaluation. Several articles highlight the importance of local authorities, in developing S.PSS-enabling policies as well as supporting novel networks of stakeholders in the co-production of value.Finally this Introduction highlights key issues for a design research agenda, including but not limited to the development of new knowledge to support S.PSS designers (such as S.PSS design in low and middle-income contexts) and the role of Higher Educational Institutions (HEIs) in the diffusion of knowledge and know-how to companies. Together, the papers in this special volume provide insight into the promise of the S.PSS concept for understanding, advancing and accelerating sustainability.

Keywords: Sustainable Product-Service Systems, design for sustainability, system innovation

Highlights

- Papers on S.PSS design and key issues for a research agenda are presented
- New ways to examine user satisfaction and design for acceptance of S.PSS are proposed
- The role of design as facilitator of complex societal change processes is examined
- Public policy especially at local level is seen as crucial in S.PSS innovation
- Key emphases for design are novel stakeholder interactions and cyclic testing processes

1. Sustainable Product-Service Systems: a promising model not widely implemented

In the last few decades, the reaction of humankind to sustainability problems has produced a series of approaches that have gone from relying upon end-of-pipe pollution control approaches to cleaner production to eco-design and product Life Cycle Design. Although these types of interventions are fundamental and necessary, the improvements they can provide are often more than offset by the pace and scale of population growth and increasing consumption levels. There is an urgent need not only to address production processes, products and provision of services, but to also redesign the patterns of consumption ("lifestyles"), as well as the institutions that underpin them – and to learn how all of them can be addressed simultaneously, to make the transformation to sustainable societal processes. In the current economic and social crises, we are facing rising prices, unstable supply chains, global food crises, inflation, recession, rising unemployment, credit crises and citizens' lack of confidence in government, the financial system and in many other societal institutions. These crises can and must be transformed into opportunities, and the current challenging and ever-changing context can help drive the change. But do we have the will, know-how and persistence to identify and seize the opportunities as they arise? Are there models capable of creating equitable and sustainable economic and social values that are decoupled from material and energy consumption and which are socially and ecologically sustainable?

A promising way to begin to address the challenges is via the Sustainable Product-Service System (S.PSS) approach, which has been studied since the end of the 1990s (Goedkoop et al. 1999; Brezet et. al 2001; Charter and Tischner 2001; Manzini and Vezzoli 2001; Brezet et al. 2001). Various research projects have been funded by the European Union (EU) and by the United Nations Environment Programme (UNEP) over the past decade with the aim of developing and testing methods and tools for S.PSS design, the main ones being *SusHouse*,[1] *ProSecCo*,[2] *HiCS*,[3] *MEPSS*,[4] *SusProNet*[5] and *D4S*.[6] The most recent is the LeNS project (www.polimi.lens.it), which was designed to integrate and update what was produced in the projects referred to in the previous sentence and to make the findings and knowledge widely and easily available free of charge on the Internet.

We defined S.PSS as *"an offer model providing an integrated mix of products and services that are together able to fulfil a particular customer demand (to deliver a 'unit of satisfaction'), based on innovative interactions between the stakeholders of the value production system (satisfaction system), where the economic and competitive interest of the providers continuously seeks environmentally and socio-ethically beneficial new solutions"* (Vezzoli et al. 2014).

Compared to the traditional product sales model, within a S.PSS model a company can improve revenues if it can meet the same demand by providing a less resource-intensive product and related service mix. Cost savings for the producer/service-provider result from reduced quantities of product materials, streamlined managerial costs and reduced costs from prolonged responsibility for the product, throughout its use and disposal. In other words, compared to a traditional product sales offer, in a S.PSS approach it is in the economic and competitive interest of the producer/provider to foster continuous innovation in reducing the environmental impacts and improving social equity and cohesion.

During the use phase, the producer has a potential economic interest to reduce the amount of resources consumed, because profit is dependent on the cost per unit of service provided to the customer. Furthermore, since the producer/provider remains the 'owner', or at least retains some responsibility for the product over its life cycle, there is an economic incentive to extend the product's lifetime. In this way, the producer, in essence, postpones both the disposal costs and the costs of manufacturing a new product. As well, at the end of the product's life, the producer has the potential economic interest to re-use or re-manufacture components to save on landfilling costs and new component manufacturing. Furthermore, the producer will be economically motivated to look into other ways to extend material life, such as by updating, repairing, remanufacturing, recycling, energy recovery or composting.

The benefits for the customer/user arise from the fact that S.PSSs cut initial investment and running costs. The benefits that accrue are not only economic, but also more widely socio-ethical, as S.PSSs can broaden access to useful goods and services to lower income strata (Vezzoli et al. 2014). In other words, S.PSS offers are focused on access rather than

[1] SusHouse: Strategies towards the Sustainable Household (EU funded, 1998-2000) (see: Vergragt 2000).
[2] ProSecCo - Product-Service Co-design (EU funded, 2002-2004).
[3] HiCS - Highly Customerized Solutions (EU funded, 2001-2004) (see: Manzini et al. 2004).
[4] MEPSS - MEthodology for Product Service System development (EU funded, 2002-2005) (see: van Halen et al. 2005).
[5] SusProNet: Sustainable Product-Service co-design Network (EU funded, 2002-2005) (see: Tukker and Tischner, 2006b).
[6] Design for Sustainability (D4S): A Step-By-Step Approach (UNEP funded, 2005-2009) (see: Tischner, Ryan and Vezzoli 2009).

ownership: they lower or allow users to avoid the initial investment (e.g. people with low incomes do not need to purchase a solar panel outright) as well as the running costs (e.g. if the solar panel breaks accidentally there is no direct cost for repair). In addition, S.PSS offers are more focused on the context of use, because they do not only sell products: they open (and/or lengthen) relationships with the end user. This should trigger a greater involvement of (more competent) local, rather than global, stakeholders, thus fostering and facilitating the reinforcement and prosperity of the local economy. Finally, since S.PSSs are more labour and relationship intensive, they can also lead to an increase in local employment and a consequent dissemination of skills.

Apart from the sustainability advantages, benefits for the customer/user and the producer/supplier include the following:

For the customer, an S.PSS is seen to provide value through more customisation and higher quality. The service component, being flexible, can also deliver new functionality better suited to customer needs and is often described as removing administrative or monitoring tasks away from the customer and back to the manufacturer (Baines et al. 2007). Business-to-business (B2B) customers tend to outsource secondary tasks at any rate, and here they can concentrate on their core competences (Meier et al. 2010). Individual users (in business-to-consumer sectors, B2C) are also freed from the burden of responsibilities that do not relate to satisfying the particular need in question. For example, they are freed from caring about washing machine maintenance and end-of-life procedures, when the need is to have clean clothes.

The advantage on the customer side is a higher level of productivity because of better use of the product's performance and the longer operation possibility. For most S.PSS cases, the customer receives value in a form that is close to current need and/or want ("unit of satisfaction").

The S.PSS benefits for companies result from *improved strategic positioning* (UNEP 2002), which is tied to the potential added value perceived by clients. By focusing on the utility delivered from a product-service mix, the company frees the client from the costs and problems associated in the acquisition, use, maintenance and disposal of equipment and products.

It is important to underline that not all shifts to PSS result in environmental benefits: a PSS may need to be specifically designed, developed and delivered, if it is to be highly eco-efficient (Vezzoli et al. 2014). For example, schemes where products are borrowed and returned incur transportation costs (and the resultant use of fuel as well as pollution emissions) over the life of the product. In some specific instances, the total fuel cost and environmental impact may make the system non-viable in the long term. Furthermore, even when well designed, it has been observed that some PSS changes could generate unwanted side effects, usually referred to as rebound effects (Vezzoli et al. 2014). Society as a whole is a set of complex, inter-related systems that are not clearly understood. As a result, unforeseen circumstances may turn potential environmentally sound solutions into increases in global consumption of environmental resources at the practical level. One example is the impact of PSS on consumer behaviour where leasing, rather than ownership of products, could lead to careless (less ecological) behaviours.[7]

Because of the potential of S.PSS to deliver social well-being and economic prosperity while operating within the limits of our planet, the research community has been inspired to collect and analyse an extensive number of cases in diverse sectors, to increase our understanding of the potential benefits, drivers and barriers, and to develop and to test several design methods and tools to be able to enhance the array of S.PSSs that are implemented globally. This is urgently needed because, despite all the knowledge and experience that has been accumulated, there remain gaps in the research as well as a significant gap in how all this knowledge is transferred to implementation. The following section will outline the main implementation and diffusion barriers to wider adoption of S.PSS models in our current understanding.

2. S.PSS implementation and diffusion barriers

Despite the aforementioned potential benefits and drivers, the diffusion of S.PSSs is still limited. An important reason is that this kind of business concept, in most cases, brings significant corporate, cultural and regulatory challenges. The following sections illustrate the barriers faced by organisations in implementing and diffusing S.PSS solutions and the ones faced by customers in accepting this type of value proposition. It is important to highlight that it is the interplay between

[7] It is from this perspective that this article promotes the term Sustainable Product-Service System (S.PSS) instead of simply PSS, when the offer is effectively a win-win proposition: environmentally, socio-ethically and economically sustainable at the same time.

different factors, rather than individual factors themselves, that determines the receptivity of S.PSS (defined as the ability of an organisation to accept, absorb and utilise the S.PSS concept) (Cook et al. 2006).[8] The focus is mainly on industrialised contexts (as most of the research undertaken so far on S.PSS refers to these contexts) and on the B2C sector.

2.1 Barriers for companies and service providers

The main internal barrier for companies is related to the fact that the adoption of an S.PSS strategy is more complex to manage than the traditional way of only delivering products. For this reason there is the *need to embed a PSS culture within the organisation* (Martinez et al. 2010). In other words *changes in corporate mindset and organisation* are required in order to support a more systemic innovation and S.PSS-oriented businesses (UNEP 2002). Cook et al. (2006) showed that the receptivity of S.PSS is more likely to happen in organisations where service transactions were already put in place. Since the capabilities and knowledge for producing and selling products are considerably different from those of managing S.PSSs, it is clear that *companies require new competences, skills and experiences,* in relation to both management and design activities. This means there is the need to: 1] structure the organisation in a way to be competent in designing, making, and delivering S.PSS offers (Baines et al. 2007); 2] acquire S.PSS design methods and tools to develop and assess them (UNEP 2002); 3] acquire life-cycle costing methods (ibid.); and 4] develop performance metrics to measure the organisation's ability in effective and efficient delivery of S.PSS offers (Martinez et al. 2010).

For these reasons company personnel need to be trained and additional personnel may be needed (Mont 2004a). It has to be underlined that these changes may be hindered by *internal conflicts between business functions* (Stoughton et al. 1998; White et al. 1999; Fishbein et al. 2000). These conflicts may be augmented by the *absence of an internal common language and alignment of mind-sets* (Martinez et al. 2010).

The lack of organisational commitment is an additional supply side factor influencing success and failure of S.PSS (Bartolomeo et al. 2003). Another internal barrier is due to the *changing of systems and sources of gaining profit* (Mont 2004a): S.PSS business models require medium- to long-term investments compared to the short-term profits generated at the point-of-sale. Consequently S.PSSs are connected with uncertainties about cash flows (Mont 2004b), which may cause producers to perceive S.PSS businesses as more risky than product-based ones (EC 2001). In addition, Small and Medium-sized Enterprises (SMEs) are often unable to finance these kinds of business models, given their usually limited financial resources (Besch 2005).

A further obstacle is the difficulty of quantifying the savings arising from S.PSS in economic and environmental terms, in order to market the innovations to stakeholders both inside and outside the company, or to the company's strategic partners (UNEP 2002).

Regarding the relationships with stakeholders along the value chain, the development and delivering of S.PSSs requires the building of strong collaboration among the actors. This may be a potential barrier, because of the *fear of sharing sensitive information* about companies' processes, products and technologies (Mont 2004a). Another obstacle is that partnerships and entrepreneurial interdependence may result in reduced control of core competencies and reduced influence on business decisions (UNEP 2002). In relation to the value chain, another barrier is represented by the potential *conflict of interests* between companies that aim to reduce sales volumes of material products and traditional interests of retailers that aim to increase sales (Cooper and Evans 2000).

2.2 Barriers for customers

As documented by Mont (2004a) and Catulli (2012), customers have a lack of knowledge and understanding about the S.PSS concept. This generates uncertainties related to unclear risks, costs and responsibilities and can lead customers to misapprehend the benefits of an S.PSS offer. Many customers (especially in the B2C sector) also lack a general understanding about life cycle costs (White et al. 1999; Bartolomeo et al. 2003). It is, therefore, challenging for them to understand the potential economic benefits of S.PSS-oriented solutions. S.PSS-based offers are often perceived by the end-user as more expensive if compared to the purchase of products, even if the opposite may be true: the initial investment cost may be lower, as well as the total cost of ownership, including use, maintenance, repairs and disposal costs, which are usually not taken into consideration by the final user in the purchase of a product. In fact, as underlined by Mont and

[8] In this regard, Cook et al. (2012) showed that organisations operating in different sectors face different sets of barriers (in particular their study compared the manufacturing and the construction sectors).

Plepys (2008) in their study on S.PSS, consumer behaviour has been found to be far more complicated than merely a rational response to prices, because customers are influenced by different internal and external drivers, induced by human psychology, social norms and institutional settings. In this regard, the main barrier is the cultural shift necessary to value an ownerless way of having a satisfaction fulfilled, as opposed to owning the product (Goedkoop et al. 1999; Mont 2002; UNEP 2002; Catulli 2012). The problem is that solutions based on access (e.g. sharing) contradict the dominant and well-established norm of ownership (Behrendt et al. 2003), making consumers hesitant to accept ownerless-based solutions (Goedkoop et al. 1999; UNEP 2002). This is especially true for particular types of needs (e.g. for washing our clothes, we are not accustomed to the idea of a washing machine in our home that does not belong to us), while in other cases ownerless-based solutions have entered into our routines (e.g. the use of public transport services). It has to be emphasised that compared to private customers, business customers tend to prefer functional sales to product ownership (Alexander 1997; Stahel 1997). Moreover, as underlined by Wong (2004), the diffusion of an S.PSS in the consumer market is highly dependent on being sensitive to the culture in which it will be used. For instance S.PSSs have been more readily accepted in communal societies like Scandinavia, the Netherlands and Switzerland than in many other countries (Wong 2004).

Another barrier to the diffusion of ownerless-based solutions is the fact that the quantity and quality of accumulated goods is perceived as a measure of success in life, because it is an indicator of a certain position in society (Mont 2004b; Catulli 2012). Moreover, as underlined by Halkier (1998), the current trend towards individualisation is boosting consumption demand, because a person's identity is no longer defined by a community but rather by the goods s/he owns, goods that represent the signals of one's own identity. In this context, refurbished products and sharing schemes may be perceived as second-class status (Mont 2004a). However, the rising of a sharing economy (Heinrichs 2013) and collaborative consumption (Meroni 2007; Botsman and Rogers, 2010) is seen as a window of opportunity that can be exploited to favour the acceptance of S.PSS-oriented solutions.

Mont (2004a) observed that for certain S.PSS categories, providers have to develop systems for monitoring and managing the product's condition at customer sites. This entails entering customers' facilities and gaining access to information about some of the customers' activities. The privacy issue, for some customers, may be a sensitive one. In addition, hesitation towards offers based on ownerless access and sharing can also be linked to the perception of independence, hygiene and intimacy usually connected to one's own products (Catulli 2012).

2.3 Context-related barriers

The environmental and social impact costs (called externalities as far as they are not included in market prices) are key context-related factors contributing to reinforcing traditional product sale offers and hindering S.PSS-based solutions. In other words, since environmental and social costs connected to products are not included in their market prices, it can become difficult for S.PSS solutions to compete with industrially produced products (Mont and Lindhqvist 2003). For this reason, as underlined by Cleff and Rennings (1999), governmental intervention is required to implement policy measures capable of internalising externalities and, as a consequence, stimulate environmental and socially sustainable innovation. However, as underlined by Mont (2001), traditional policy instruments targeting product environmental performances are not sufficient to achieve this objective. Governments should intervene by implementing policy measures capable (directly or indirectly) of stimulating the diffusion of S.PSSs (Mont and Lindhqvist 2003; Ceschin and Vezzoli 2010).

Moreover, the cost of labour is increasing and therefore it can be cheaper for customers to buy product-based offers (e.g. buy a washing machine) instead of labour-intensive solutions like S.PSS-based offers (e.g. clothing care services). In addition, other context-related barriers may include a lack of external infrastructure and technologies (e.g. for product collection, remanufacturing or recycling) (UNEP 2002).

3. Research questions addressed in this Special Volume

Given the implementation and diffusion barriers described above, this Special Volume (SV) was designed to contribute to identifying the new design opportunities and obstacles in S.PSS diffusion as well as highlighting the key issues for an S.PSS design research agenda. In order to accomplish this objective the Call for Papers (CfPs) (Vezzoli et al. 2012) raised the following main questions.

- How do S.PSS innovations evolve?

    - What are the dynamics and factors that facilitate and hinder the process of introduction and scaling-up of S.PSSs?
    - How can firms organise and manage the shifts towards S.PSS-oriented business approaches?
    - What role(s) can different stakeholders play in stimulating these processes?
- What strategies, approaches and tools can be adopted to trigger the scaling up of S.PSSs?
    - How can concepts such as socio-technical experiments, transition experiments and living labs trigger, guide and sustain these processes?
    - What kinds of design approaches, methods and tools can be used to improve the quality, breadth, depth and spread of the needed changes?
- How do/can final users influence the introduction and scaling-up processes?
    - What strategies and approaches can be adopted to stimulate people to accept new consumption models?
    - How can/should S.PSSs be designed to stimulate behavioural changes and to foster user acceptance and satisfaction?
- How can changes in economic and legal frameworks foster and accelerate the implementation of S.PSS innovations?
    - What governmental, regional and local policies can be developed and implemented to specifically favour the introduction and scaling-up of S.PSSs?
- What synergies can be built with other promising models?
    - Are there cases that document the synergistic benefits of using different combinations of approaches, concepts and tools? What can we learn from them that can help us to speed up the up-scaling processes?

The following queries posed in the CfPs were not addressed in the papers in this SV, but remain important and compelling areas of inquiry for future research, as described in section 5:

- What are specific characteristics of transition processes in different contexts (industrialised, emerging and low-income)?
    - What are the similarities and differences, as well as the specific challenges and opportunities?
- What are the challenges/opportunities for Higher Educational Institutions (HEIs) to help to facilitate the necessary transitions?
    - What knowledge and know-how should be provided to challenge students to become active change agents within the transformation of our consumption and production *patterns to truly sustainable patterns?*
    - What educational strategies and approaches should be put into practice to accelerate the widespread development and adoption of S.PSSs?

4. New design opportunities and obstacles in initiation and diffusion of S.PSS

The papers in this SV provide a range of contributions, reflections and insights, which can be grouped into four main clusters: *S.PSS design of user acceptance and satisfaction*, *S.PSS design of industrial partnerships and stakeholder interaction*, *S.PSS design and socio-technical change* and *S.PSS and policy approaches*. For each cluster, the following sections briefly sum up the topic and highlight the most relevant research, present the related papers and discuss their original contributions.

4.1 Sustainable Product-Service System design of user acceptance and satisfaction

A key reason for pushing the adoption of S.PSS solutions is to drastically reduce resource consumption and negative environmental impacts without reducing people's sense of well-being and satisfaction. However, as described in section 2.2, a significant barrier to S.PSS diffusion relates to user acceptance and adoption of these novel systems. This may be due to existing habits, how the service provider is perceived, financial reasons or other empirically documented factors that make users feel unsure (e.g. Rexfelt and Hiort af Ornäs 2009). These obstacles are of special concern if we seek radical change. That is, radically new S.PSS configurations will challenge the status quo the most, but they also have the most potential for positive impact, in particular result-oriented S.PSSs (Tukker and Tischner 2006a). The most novel production and consumption offerings will nevertheless require long-term strategies and transition-oriented design, as described in section 4.3, preferably supported by smart policies (section 4.4). In this strategic process, profound understanding of the consumer/user is central – the user's attitudes and values, lifestyles and habits, and behaviours and motivations.

During the development of this SV, It was found that despite a growing tradition and knowledge base in S.PSS exploration, in both research and practice, successful commercial S.PSS examples are still more likely to be B2B than B2C offerings (Catulli et al. 2013; Tukker in this volume). This emphasises the importance of this knowledge gap: user (or citizen) acceptance in B2C solutions and how value is perceived or co-produced (Ramirez 1999). It requires understanding what alternatives users already have in place, to better gauge what they may choose, from, for instance, the perspective of user-centred design and consumer research (Rexfelt and Hiort af Ornäs 2009; Catulli 2012; Catulli et al. 2013). It requires understanding the user as part of a group or community, from the perspectives of marketing, sociology, psychology and other fields. It requires understanding how S.PSS solutions geared to consumer lifestyles can actually lead to environmental benefits, from the perspective of ecological economics (Halme et al. 2004), environmental management and material footprint studies (Lettenmeier et al. 2014) and from other fields.

As stated in the foregoing paragraphs, this evidence base is expanding, but many studies continue to be conceptual and explorative, according to Boehm and Thomas's (2013) literature review. When empirical studies and case studies are conducted, a complication arises because their findings are problematic to generalise (Meijkamp 2000). One way to combat this is to seek to make progress even when hard evidence is lacking. Design skills can play a particular role here, especially the skill to prototype, iterate and perform constant interim evaluations (Morelli 2003; Rexfelt and Hiort af Ornäs 2009). According to Ceschin (2014b), this is the role of S.PSS design as a Lab.

This leads this editorial team to pose the question of how to design and implement S.PSS solutions, keeping in mind the importance of user acceptance. For example, Rexfelt and Hiort af Ornäs (2009) and Krucken and Meroni (2006) emphasised the need to develop both the S.PSS and its communication simultaneously. Tools and methods can and should be borrowed from other fields, as in the case of a service quality measurement tool to measure customer satisfaction and perceived quality in Catulli's study of car sharing and nursery equipment (2012). However, S.PSSs have unique attributes that are not all amenable to existing evaluation tools. Mont and Plepys (2003) therefore recommended the use of multiple tools and the need to evaluate customer satisfaction in four areas relevant to PSS: product, service, infrastructure and networks.

At face value, these questions about S.PSS design, implementation and diffusion do not differ from the questions contemporary product and service designers need to ask: what do we need to know about consumers and end-users, how do we identify needs in a rapidly changing world, who and what is the competition, and how do we best access that information and build that knowledge? With regard to sustainability and seeking positive change, the questions are similar, whether this involves the public sector concerned about its citizens' health or environmental organisations seeking to lower carbon emissions: what is the evidence base upon which we can build and go forward? Research on designing S.PSSs appears to be bringing the two perspectives together: the practicality of commercial approaches with the normative goals inherent in Sustainable Consumption and Production initiatives.

The unit of analysis of user acceptance in S.PSS has often been consumer *behaviour*, and frameworks have been developed to examine existing behaviours and routines in order to identify what pro-environmental behaviours can be encouraged by design (e.g. DEFRA 2008) and how to break bad habits (Power and Mont, 2010). This behaviour-led approach is problematic on its own, however, or in certain sectors, because of the behaviour-attitude gap (Kollmuss and Agyeman 2002). A more helpful construct may rather be via *use regimes*: "a set of technological, economic, and social elements such as infrastructure, attitudes and values, institutional arrangements, price relations, and symbolic meanings of products that determine consumer behaviour" (Hirschl et al. 2003, 877).

Mylan (in this volume) suggested that 'practice theory' might offer a promising way to better understand supply and demand dynamics. Practice theory, a new approach in the sociology of consumption (Røpke 2009; Shove et al. 2012), takes these symbolic meanings into consideration. It is also designed to address and to describe the everyday behaviour patterns entrenched in habits and routines: patterns that may be problematic or not obvious to study by virtue of their very mundaneness. By analysing how materials, meanings and skills are woven together, practice theory may contribute to a sustainability analysis by making more visible the material elements in S.PSSs. The study illustrated these dynamics through the examples of energy-efficient light bulbs and low temperature laundry. Moreover, Mylan argued that the conventional focus on user needs in S.PSS design is often done in the context of the status quo, which does not lead to innovations or transformations – sustainable or otherwise. Since changes in practices depend on how strongly practices are coupled or

linked to each other (as well as the elements within a practice), and an innovation or intervention may experience resistance in strongly linked practices, Mylan suggested that, "diffusion may be better understood by investigating alignment processes than by asking about 'barriers'".

Piscicelli et al. (in this volume) sought to reconcile the two: to account for both social psychological models of behaviour and social practice theory. The authors argued that this approach can help counter the behaviour-attitude or value-action gap (Blake 1999), by moving beyond behaviours to practices. It can also address individual norms that may be out of the frame of analysis in social practice theory. The authors reported on a quantitative study of an online marketplace, which they described as a model of collaborative consumption (Botsman and Rogers 2010). When comparing these collaborative consumers to the average consumer or user in the UK, the authors found that these S.PSS users seemed to share a distinct value orientation. A subsequent study will examine the same case, and the relationships between values and engagement, but through the lens of practices. The interlinkages between materials, meanings and skills in practice theory and values and behaviour in social psychological models of behaviour can help clarify how S.PSSs can be designed and implemented to encourage user acceptance and adoption.

It may be considered problematic that relatively few radical S.PSS examples currently exist and therefore, user acceptance remains a black box. Armstrong et al. (in this volume) attempted to shed light on these novel business models in the context of the clothing industry, an industry marked by environmental problems related to overconsumption and excessive amounts of pre-consumer and post-consumer waste. The authors' strategy in this case was to set up focus groups and a set of scenarios designed to help determine the threshold of acceptability of a range of S.PSS solutions related to clothing. While the findings confirmed many of the barriers and enablers discussed in other studies (see sections 1 and 2), the environmental benefits linked to the solutions gained surprising prominence. Several solutions were regarded as realistic and viable, while others, especially those related to collaborative consumption type models, were considered to be less realistic. The authors suggested how some solutions were more appealing to certain user groups and their shared values. To this editorial team, the findings also indicated the need to design implementation roadmaps.

This may be a design implication for all three studies: the need to incorporate incremental steps in a path or practice, especially to the most radical S.PSS solutions. Moreover, identifying and catering to the right customer groups still faces the very 21st century challenge of fragmentation and 'markets of one' (Gilmore and Pine 2000). There may, therefore, be valuable lessons transferable to S.PSS design from other fields such as mass customisation, especially regarding the role and authority of the customer and co-creation. These lessons include where and when co-creation involving both producer/provider and customer should occur and when the customer can take over and customise the S.PSS solution to his or her satisfaction. For certain types of S.PSS (remembering the perils of overgeneralising), customisation and innovative co-production approaches may offer the best path for a user to ensure "seamless" provision of an S.PSS and its upgrade (Catulli 2012) as situations change. In Piscicelli et al. (in this volume), what was found to be especially salient was the nature of the model, neither B2B nor B2C, but a C2C (or P2P, peer-to-peer) model. This finding presents its own set of challenges and opportunities, as described in section 5.1.

If we focus on user acceptance, are we simply catering for, legitimising and consolidating a status quo condition that was unsustainable from the outset? The studies in this SV seem to indicate that it is possible – and necessary – to understand, satisfaction (needs and/or wants), user acceptance, behaviour, routines and the potential for change and transformation in much more nuanced ways.

4.2 Sustainable Product-Service System design of industrial partnerships and stakeholder interactions

Many industrialised nations are witnessing a contraction in their manufacturing sectors caused by a shift of production to low-cost economies. Companies continually strive to increase production, but in recent years, the effects of this effort have demonstrated that providing products alone is insufficient in terms of remaining competitive (Yu et al. 2008). In order to combat this, manufacturing firms have moved away from seeking competitive advantage from process or product innovation to "servitising", by integrating value-added services with their core offering (Lockett et al. 2010). The development and implementation of Product-Service Systems in this situation can provide an alternative way for companies to increase market share as well as customer satisfaction (Beuren et al. 2013). Such a strategy is a means by which Western manufacturers can face the challenges from lower cost economies. Traditional manufacturing firms with well-developed capabilities in terms of products and processes will find the transition to servitised organisations to be a

difficult process (Baines et al. 2009). One of the main challenges is construction of new industrial partnerships and stakeholder interactions.

As stated by Morelli (2006), an S.PSS is a social construction based upon “attraction forces” which catalyse the participation of several partners. An S.PSS is the result of a value co-production process within such a partnership. The proposition of value through products and services embraces a complex network of suppliers and competencies (Tan 2010). Consequently, strategic partner management is one of the critical success factors for S.PSSs. S.PSSs are forcing a new understanding of relationships (Cavalieri and Pezzotta 2012). New innovative partner networks play an important role in this. According to Laperche and Picard (2013) one of the main characteristics of S.PSS innovation management changes lies in the development of innovative partnerships. In order to form and maintain their knowledge capital firms not only need to rely on internal resources but should engage in many cooperative relationships with external partners (Laperche 2007). Partnerships are not only made for additional skills embodied in human resources and expert knowledge, but also for knowledge around their core research area to provide additional and complementary knowledge. In addition partnerships appear to be a way to increase innovative efficiency in a competitive environment. In order to address all these goals, partnerships are developed in many directions, which require different types of partners (Laperche 2007).

From a partnership perspective, supply chain management and product life cycle management play critical roles as well. Aurich et al. (2010) explained that with S.PSS development, “companies have to shift their designing and selling products only, to support and accompany their usages and end-of-life management. So they have to take care of life cycle phases that are usually outside the traditional buyer-seller relationship. Contrary to other business models, the life cycle management of PSS focuses on the design and realization of required user functionalities over the whole product life cycle”. When designing partnerships it is important to specify each partner’s value and involvement throughout the product life cycle (Sakao et al. 2009; Cavalieri and Pezzotta 2012).

While there is a considerable body of academic knowledge on the role of upstream supply networks in the contexts of traditional manufacturing (e.g. pure products), there is less work in the context of S.PSS (Lockett et al. 2010). Information flow management (i.e. sharing of information between supply chain members) is one of the particularly important issues in the use of servitisation strategies. Also downstream at the interface between S.PSS provider and customer there is a need for a closer relationship between the stakeholders (Lockett et al. 2010).

How these novel partnership networks and strategic stakeholder interactions can make S.PSSs successful as well as how they support environmental and social sustainability goals has been little studied. Nevertheless they seem to be crucial for new, emerging sustainable industries as, for example, electric vehicles (Cherubini et al. in this volume) and for socially oriented initiatives dealing with problematic issues such as waste re-use (Gelbmann and Hammerl in this volume).

In the electric car industry the service component assumes considerable importance, and it is a relevant factor in purchasing decisions. Cherubini et al. (in this volume) elaborated a new approach for identifying critical success factors (CSFs) in S.PSS. Their paper focused upon the electric car industry, an innovative product-service system designed to achieve critical mass, for which an S.PSS analysis (rather than a conventional industry-specific perspective) was deemed to be appropriate. The ten main CSFs were classified with regards to their relevance and their manageability. This approach helped the authors to demonstrate that partnerships represent a priority factor requiring immediate action in these companies. Consequently, it may be particularly useful for the analysis of an innovative S.PSS in the introductory phase of its life cycle because the achievement of critical mass is a prerequisite for market development and requires the involvement of a number of different actors. Even competing companies can act in partnership for achieving this goal.

Gelbmann and Hammerl (in this volume) analysed the structure of a S.PSS, in the case of ECOlogically oriented Work Integration Social Enterprises (ECO-WISEs). This was and is being accomplished through the use of the business model canvas (Osterwalder and Pigneur 2010) combined with a comprehensive stakeholder consideration, showing the relevance of re-use practices to promote the three dimensions of sustainability. The authors unpacked the value propositions offered by the ECO-WISEs studied (i.e. long tradition in the business, not-for-private-profit and high degree of creditability). They offered proposals on how such enterprises can find acceptance and can mainstream their S.PSSs. Successful mainstreaming is essential since currently, re-use is restricted to niches, but by 2020 the European Commission wants to mainstream re-use as a waste management option to increase resource efficiency. ECO-WISEs stand out from many organisations, not only because the re-use of waste holds a curious position in industrialised economies and legislation, but also because of their unusually wide and diverse stakeholder network that needs to be in place to best ensure diffusion.

This SV also features two literature reviews, Reim et al. (in this volume) and Tukker (in this volume). Reviews of this kind have value in synthesising findings from various studies and identifying future research potential, and they can also shed light on synonymous terminology and their related studies that may otherwise be overlooked by S.PSS researchers and practitioners (such as 'functional sales').

Reim et al. (in this volume) explored the research on the implementation of S.PSS business models and their operational tactics, in their systematic literature review. Among the findings is confirmation of the most commonly accepted typology of S.PSS, as proposed by Tukker (2004): the papers reviewed were in three distinct categories of business models, product-oriented, use-oriented and result-oriented models. Implementing a particular business model then requires particular tactics, which are designed to strategise how much value is created and captured. In their review, five prominent tactics were identified, related to contracts, marketing, networking, product and service design and sustainability. Sustainability emerged as an important topic, which was described as the ability of S.PSS providers to fully capture environmental and social value, linking it to economic value via resource efficiency and/or competitiveness via innovation, and avoiding negative consequences such as rebound effects.

Tukker's (in this volume) review was broader than Reim et al.'s survey, as his review included all papers addressing PSS with the special objective to update the literature synthesis in his and his colleague's previous literature review (Tukker and Tischner 2006a). The reviewer also summarised various definitions, design methods, disadvantages and benefits of S.PSS, in business and environmental terms, as found in the literature, as well as the related evaluative frameworks. Tukker's review found a lack of environmental focus in the literature reviewed, with more attention having been given to how PSS models enhance competitiveness. According to Tukker, the recent literature is notable especially for its contribution to understanding how PSS models have been implemented in an organisation and what key success factors and issues deserve special attention, such as a focus on product availability for clients; an emphasis on diversity in terms of services provided rather than on the range of products; and the need for staff to possess both knowledge of the product and relationship management skills. The reasons why S.PSSs have not been widely implemented, particularly in the B2C context, seem to have been already explained in the literature available in 2006. For consumers, having control over things, artefacts and life itself is one of the most valued attributes.

4.3 Sustainable Product-Service System design and socio-technical change

It has been argued that S.PSSs may require a profound redefinition of the production and consumption modalities (and their established and relatively stable set of rules and networks of actors) (Tukker and Tischner 2006a; Ceschin 2013). An important challenge is therefore not only to conceive S.PSS concepts, but also to understand the contextual conditions in which they are introduced and to explore the suitable strategies and development pathways to embed these concepts in society.

Recent advances in the field of *transition studies* (in particular the contributions from *Strategic Niche Management* (SNM) and *Transition Management* (TM) approaches) have provided insights into how to understand, influence and orient the adoption of radical innovations. Through historical socio-technical case studies, transition scholars have analysed how radical innovations take place and have elaborated a model called the multi-level perspective on transitions (Geels 2002) that describes the dynamics regulating these complex and long-term processes. These dynamics depend on the interactions among three functional levels (Geels 2002; 2005): the *socio-technical regime (meso level)* which refers to the dominant and relatively stable set of culture, practices and institutions related to a specific field (mobility, energy, etc.); the *niche (micro level)*, a protected space "isolated" from the influence of the dominant regime, where radical innovations can be tested, become more mature, and can potentially challenge and change regime practices and institutions; and the *landscape (macro level),* which represents the social, economic and political context in which actors interact and regimes and niches evolve.

According to transition scholars, the introduction of radical innovations requires the creation of partially protected socio-technical experiments (Kemp et al. 1998; Hoogma et al. 2002; Brown et al. 2003; Raven et al. 2010; Van den Bosch 2010). Protection allows incubation and maturation of radical socio-technical configurations by partly shielding them from the mainstream market selection environment. A pathway of socio-technical experiments can be used as a strategic arena for learning, shaping future expectations and establishing new social networks in order to gain momentum for diffusion and challenge and change socio-technical regimes (Raven 2005; Van den Bosch 2010).

Researchers in the design field have recently started to build upon concepts and insights from transition studies and to explore the role of design in relation to large-scale changes. Vezzoli et al. (2008) introduced the idea of designing transition

paths to support the experimentation and scaling up of S.PSSs. Ceschin drew from TM and SNM to formulate a conceptual framework to account for S.PSS implementation (Ceschin 2012; 2013) and investigated the role for strategic design in supporting transition paths (Ceschin 2012; 2014a). Gaziulusoy (2010) and Gaziulusoy et al. (2013) developed a theoretical and operational framework to link activities or decisions at the product-service development level in organisations with the transformation, which needs to take place at the societal level to achieve sustainability. Cook (2014) drew on sustainable architecture to formulate the concept of "*fluid transitions to sustainable PSSs"*. Manzini, Meroni and Jégou have proposed (even if they did not explicitly refer to S.PSS) three broad design strategies to scale-up radical innovations: *enabling*, *replicating* and *synergising* (Jégou and Manzini 2008; Meroni 2008; Jégou 2011).

Design researchers have also started to investigate how to design socio-technical experiments to better trigger and support socio-technical changes. Ceschin (2014b) proposes to design experiments as *Labs* (to test, learn about and improve the S.PSS innovation on multiple dimensions), *Windows* (to raise interest in the innovation project and the related actors, disseminate results, build up synergies with existing similar projects/initiatives, and attract and enrol new actors) and *Agents of change* (to influence contextual conditions in order to promote and quicken the transitioning process). The MEDEA institute at Malmö University proposed to use Living Labs[9] to experiment, explore and support the scaling-up of grassroots social innovations (Hillgren et al. 2011). In line with Malmö Living Labs, Manzini proposed the concept of *"Enabling Experiments"*[10] to refer to the implementation of favourable environments that enable local actors to take active roles as co-creators in the development and proliferation of social innovations. Manzini and Rizzo (2011) emphasised that large-scale changes require the implementation of a multiplicity of diverse and interacting experiments. In this respect Meroni (2008) and Jégou (2011) wrote about *"synergising"* or *"acupunctural planning",* a set of synergic self-standing local experiments that adopted as a metaphor the practice of the traditional Chinese medicine, designed to generate changes in large and complex systems by operating on some of their *sensible nodes.* Finally, Mellick Lopes et al. (2011) investigated the potential of visual communication design to facilitate social learning in socio-technical experimentations.

In this SV, authors of two papers investigated the potential role of designers as facilitators of complex societal change processes. Joore and Brezet (in this volume) elaborated upon Joore's PhD study (2010) and proposed the Multilevel Design Model (MDM) to clarify the mutual relationships between new products, S.PSSs, socio-technical systems and societal changes. Joore and Brezet argued that S.PSS designers act at all levels of society and need help – in terms of mapping – to find their way through increasingly complex and interrelated innovation systems. The MDM combined a cyclic iterative design approach (reflection, analysis, synthesis and experience) and a hierarchical system approach (product, product-service system, socio-technical system and societal system). MDM was designed to support designers by providing insight into the interrelationships between S.PSS design processes and the processes that occur on the various system levels. So far, it has been applied mainly as a descriptive and analytical tool for design researchers, but future developments are anticipated to use the approach as a prescriptive tool for designers and design managers.

Liedtke et al. (in this volume) drew on the concept of the Living Lab and presented the Sustainable Living Labs (SLL) research infrastructure, an experimental setting to test and develop S.PSSs. Compared to existing Living Lab approaches the SLL infrastructure was characterised by a clear focus on sustainability innovations and PSS development, and by a unique combination of laboratory situations with real-life experiments. A methodological framework to conduct R&D on S.PSS solutions within the SLL infrastructure was also described and discussed. This approach anticipates a three-phase model based on insight research, prototyping and field testing. The SLL concept is currently being applied and tested in the EU-funded SusLab NWE project. An applicative case study on energy and resource efficiency in buildings was used to present and discuss the initial findings of the SLL infrastructure.

4.4 Sustainable Product-Service System and policy approaches

As underlined in section 2.3, governments can play a crucial role in supporting the adoption and diffusion of S.PSSs, by developing policy frameworks and stimulating proper conditions. There are three main reasons to justify the need for government intervention. 1] Environmental and social impact costs (as externalities) are currently not included in market

[9] The concept of Living Lab refers to experimentation environments in which innovations are created in real-life contexts by fostering collaboration among researchers, companies, end users and other relevant stakeholders (Ballon et al. 2005; Stålbröst 2008).

[10] The term was introduced by Ezio Manzini during his keynote speech *"To make things happen: Design as a catalyser of community engagement"* at the Design Pleasurable Product Interface 2011 conference (Milan, Italy, http://www.dppi11.polimi.it/). The keynote speech was then elaborated into a paper "Making Things Happen: Social Innovation and Design" (Manzini 2014).

prices, and as a consequence sustainability-oriented innovation is not stimulated (Cleff and Rennings, 1999). 2] The cost of labour is still relatively high compared to the cost of energy and raw materials, and this can disadvantage labour-intensive solutions such as S.PSSs (Mont and Lindhqvist 2003). 3] Due to various kinds of path dependencies, companies can be locked-in to existing business models and industrial dynamics and, as single players, cannot change such broad logics (Heiskanen et al. 2011; Plepys et al. in this volume).

As underlined by Mont (2001), traditional policy instruments targeting product environmental performances have not been sufficient to support S.PSS innovation. Although instruments such as *eco-labelling* and *Environmental Product Declarations (EPD)* can stimulate companies in "greening" their products, and can provide users the possibility to select the best option to buy, on the other hand these instruments still promote consumption based on individual product ownership (Mont and Lindhqvist, 2003). Governments should therefore intervene by implementing policy measures capable (directly or indirectly) of stimulating the diffusion of S.PSS innovations. Three main directions of actions can be identified (Ceschin and Vezzoli, 2010):

- *Creating the economic conditions* to encourage companies to shift their business models towards an S.PSS approach. S.PSS innovations may struggle to compete with traditional solutions if external costs are not internalised (Mont and Lindhqvist 2003). This, together with the fact that S.PSS innovations are linked to medium-long term investments and uncertainties related to cash flows, should encourage governments to operate in order to overcome these barriers and favour the economic viability of S.PSSs.
- *Raising consumers' awareness* to inform users about the benefits brought about by S.PSS innovations and thereby stimulate and support the shift towards consumption based on access and sharing rather than ownership.
- *Supporting information and knowledge dissemination to companies*. Since one of the main barriers to the implementation and diffusion of S.PSSs is the lack of knowledge within firms and consultancy companies, governments should act on the dissemination of information and know-how about the benefits of S.PSSs, successful S.PSS case studies and methods and tools to design and implement such innovations.

Governmental actions can be classified as *general policy measures indirectly addressing S.PSS* and *specific S.PSS-oriented policy measures* (Mont and Lindhqvist 2003; Ceschin and Vezzoli 2010). *General policy measures indirectly addressing S.PSS* refer to policies aimed at addressing environmental and socio-ethical problems without necessarily steering directly towards the development of S.PSSs. This includes: 1] *Internalisation of environmental and socio-ethical external costs* through tools such as pollution charges or taxes based on output/input of polluting units, as well as fiscal incentives for pollution abatement; 2] *Extended Producer Responsibility (EPR) programmes* (e.g. Waste Electric and Electronic Equipment (WEEE), or the End of Life Vehicles Directive), to take responsibility for the costs related to the management of their products at the end of life; 3] *Informative policy measures* (such as eco-labelling, fair-trade labelling, consumer advice, consumer campaigns), to increase consumer awareness and to inform users about environmentally and/or socio-ethically preferable solutions available in the market.

Specific S.PSS-oriented policy measures refer to measures oriented directly at stimulating the introduction and diffusion of S.PSSs. This includes: 1] *Green Public Procurement (GPP) focused on S.PSS,* to include S.PSS solutions in the public institutions' purchase guidelines and make S.PSS-based offers preferable to product-based ones; 2] *Disseminating information and know-how related to S.PSSs*, in order to support companies in acquiring an operative approach, methods and tools to design, implement and manage S.PSS innovation, as well as the skills and competencies to evaluate S.PSS from the environmental and socio-ethical points of view; 3] *Incentivising companies in acquiring information related to S.PSSs*, for example by economically supporting collaboration projects between companies and universities/research centres; and 4] *Supporting demonstrative pilot projects* (i.e. socio-technical experiments, see 4.3) aimed at wider diffusion of S.PSS solutions.

In this SV, the authors of two papers investigated how public policy can stimulate and support S.PSS innovation. Plepys et al. (in this volume) conducted a review of the state-of-the-art of policy instruments addressing S.PSS. These were classified in relation to their *direct* or *indirect* influence on servicising and in relation to the *geographical scope of government* on which they were applied (i.e. European, national and municipal levels). The authors found that policy interventions at local/municipal level were more directly targeting and stimulating the implementation of S.PSS solutions than those on the national and European levels. This is because local authorities are uniquely positioned to identify local needs and can more directly utilise specific support schemes. More generally the authors highlighted the need to place the servicising goal as a more central objective in policy design, as well as the need to optimise policy measures in order to support those servicising solutions that cause a strong decoupling between economic growth and increase in resource consumption.

Zhang et al. (in this volume) analysed the characteristics and commonalities of five bike-sharing systems in five Chinese cities, and in particular explored the role that public policy played in implementing and supporting these systems. Results from the case studies' analysis suggested that the most effective bike-sharing systems involve government-led investments, with high levels of subsidy. Where bike-sharing systems have been led by the private sector with few subsidies from local government, they resulted in a less effective solution in terms of number of bikes and daily bike usage. Successful cases also have proactive and supportive local governments. Local authorities were, in fact, involved in setting up participatory processes with potential users, in the initial phases of the design process and were committed to putting in place the right infrastructure, i.e. bicycle lanes and bicycle stations.

5. Key issues for a S.PSS design research agenda

Research hypotheses, studies and experimentations have been put forward, but the application of the S.PSS approach remains limited. It is nevertheless promising – and hopeful – that whatever constraint has been identified as limiting S.PSS implementation and diffusion, no author, including those of this SV, has argued that such an offer model is clearly *not* a solution for progress towards societal sustainability. This optimism is one of the reasons for launching this SV of the Journal of Cleaner Production and disseminating the CfPs: in the opinion of the guest editors, it is important and timely to identify a multidisciplinary research agenda and to stimulate further interest. From this perspective, and especially concerning the design discipline, to which the editors belong, this last section was designed to identify the key issues that, in the editors' understanding, should be highlighted as part of a design research agenda, aiming at the wider diffusion and implementation of Sustainable Product-Service Systems. Some of these issues are transversal to some authors' contributions to this SV, while others have not yet been addressed by the research community. Many of the issues have emerged from and have been identified because of the valuable experiences and outcomes of several EU-funded projects focused on Sustainable Product-Service System and design, in particular *the Learning Network on Sustainability (LeNS)*[11] and *the Learning Network on Sustainable energy systems (LeNSes).*[12]

These research directions can be seen in relation to the following areas: *a. Development of new knowledge to support S.PSS designer; b. Diffusion of knowledge and know-how to companies* and *c. Creating contextual conditions to support S.PSS*.

5.1 Development of new knowledge to support S.PSS designers:

- S.PSS design and user acceptance & satisfaction. The first important research direction is related to S.PSS user acceptance and satisfaction. More in-depth studies in user behaviour in relation to S.PSSs are clearly needed. As underlined by Baines et al. (2007) and confirmed in section 4.1, it is necessary to understand what factors influence user satisfaction, as well as how to measure and evaluate this satisfaction. This knowledge would be valuable in the design phase, so as to be integrated in existing design approaches and methods. This is very much linked to the issue of the aesthetics of S.PSS, i.e. a new aesthetic for sustainable services or more widely of sustainable stakeholder interactions: an aesthetic able to enhance characteristics and inner qualities specific to S.PSS (Ceschin et al. 2014).
- Another compelling research direction connected to user satisfaction is to investigate the influence that socio-cultural conditions play in fostering or hindering the acceptation of S.PSS-oriented solutions. This exploration would benefit from quantitative and life-cycle-led analyses of impacts, to determine if indeed these new socio-cultural S.PSS configurations have the potential to reduce the environmental impact and/or to improve social equity and cohesion. Relatedly, Piscicelli et al. (in this volume) investigated "collaborative consumption", a set of practices that engaged users in novel peer-to-peer interactions. As these enterprises and practices appeared to

[11] The Learning Network on Sustainability (LeNS) was activated by an EU project funded by the Asia-Link programme, involving seven design schools in Europe and Asia, to develop an Asian-European multi-polar network for curricula development on Design for Sustainability focused on Sustainable Product-Service Systems (www.lens.polimi.it).

[12] The Learning Network on Sustainable energy systems (LeNSes) is an EU project funded (2013-2016) by the Edulink programme, involving seven design schools in Europe and Africa, to develop a multi-polar network for curricula development on System Design for Sustainable energy for All (SD4SEA) focused on Sustainable Product-Service Systems applied to Distributed Renewable Energies (DRE) (www.lenses.polimi.it).

involve commitment and engagement (and critiques) that differed significantly from the consumer-producer relationships seen in conventional consumer product and service brands, it is possible that examining these solutions under the lens of e.g. social movement theory (Buechler 1995) may yield fruitful information that designers can employ in system analyses and in enabling new platform designs.

- S.PSS design and socio-technical changes. Recognising that the implementation of S.PSS might sometimes require changes in the socio-technical system, some researchers have started to investigate S.PSSs through a system's innovation perspective (Ceschin 2012; 2013; 2014; Joore and Brezet in this volume; Liedtke et al. in this volume). However, further research is needed to better understand the S.PSS introduction and diffusion process (and its critical factors) and how it can be designed, managed and oriented. In relation to the latter point it seems promising to examine the potential role of protected socio-technical experiments (or Living Labs) as a strategy to incubate, test and hasten the diffusion of S.PSS. However, practical applications are needed in order to test and validate this approach.

- S.PSS design in low and middle-income contexts. S.PSSs have been mainly studied and implemented as eco-efficiency opportunities (economic and environmental win-win models) in industrialised contexts. Considering sustainability in all its dimensions and in all types of contexts, it is of key importance to deepen the understanding of S.PSS as a promising approach to couple not only economic and environmental benefits but also socio-ethical dimensions (UNEP 2002; Vezzoli et. al 2014). This should also embrace if and how S.PSS may act as an offer model in low and middle-income contexts, for enhancing not only improvements in eco-efficiency but also in social equity and cohesion. S.PSSs are expected to be especially beneficial for low and middle-income contexts because they can cut the access costs to useful goods and services: the customer is neither required to buy the product, nor threatened by the maintenance and the repair costs.

- S.PSS design and energy systems. A specific research topic, partly within the previous point, is related to the access for all (including low-income contexts) to sustainable energy, as this has recently been recognised as a key leverage point for sustainable development (the UN has proclaimed 2014-2024 the decade of Sustainable Energy for All). In this framework a dominant opinion is calling for a shift from centralised and fossil fuel-based energy systems to Distributed Renewable Energy Systems (DRES). Accordingly, a research hypothesis worth investigating is the potential an S.PSS model may offer when applied to DRES, in particular in low and middle-income contexts, and the potential new design and development roles this transition may offer (Vezzoli, Ceschin and Diehl, in this volume).

- Integrating S.PSS with other sustainability concepts. The S.PSS concept seems to be a valuable and promising concept to tackle sustainability issues, but it does not represent a silver bullet. Thus, it is crucial to explore the potential synergies among S.PSS and other promising and interwoven sustainability concepts, such as social innovation, Distributed Economies (DE), cradle-to-cradle, and sustainability-oriented crowd-led design, -sourcing and -funding. It is unknown how these concepts can be combined to enhance the diffusion of S.PSS. This exploration can also enable a better understanding of indicators and performance measures and provide impetus for further evolvement of tools and methods for S.PSS design. Part of this exploration can and should pursue further not only the typologies inherent in S.PSS models (see e.g. van Ostaeyen et al. 2013) appropriate to a rapidly changing business environment, and updating them as needed, but also to robustly research, propose and detail new typologies of options appropriate for S.PSS models (e.g. Roy 2000).

5.2 Diffusion of knowledge-base and know-how to companies and S.PSS designers:

- *Higher Educational Institutions (HEIs)* must be much more committed to ***supporting knowledge-base and know-how dissemination*** related to S.PSS design and diffusion. HEIs, and especially those where research and education are intertwined, have indubitably key roles to play, in order to foster a new generation of practitioners and design educators. This entails supporting diffusion of knowledge within HEIs, as well as understanding the most effective strategies to transfer knowledge from research centres and universities to companies and designers (see for instance the work by Cook et al. [2006]). Tukker and Tischner (2006b) illustrate, for example, that the main challenges are to organise the available knowledge in an accessible way (including training and educational programmes) and to develop an open case base including S.PSS concepts for different sectors, different cultures

and with different consortia of stakeholders. This knowledge on tested success cases and learning tools should be made available to companies and professional designers in a manner that encourages its use in practice. Even so, it is not currently clear to what extent the existing S.PSS design approaches and tools, which have been mainly developed in academia, (e.g. Cortesi et al. 2010) are being used by companies and designers. When these tools are not used, it is also not clear if it is because companies and designers are not aware of them, because they do not understand how to apply them or because they think that the tools are not useful for them. It is in this SV's editorial team's opinion that a paradigm shift is urgently needed in the way new (design) knowledge is produced and diffused within and among HEIs and from HEIs to practitioners.[13]

5.3 Creating contextual conditions to support S.PSS:

- **S.PSS and Policy frameworks & measures.** Finally, it is also important to look at how to create appropriate contextual conditions to favour S.PSS. Governmental, regional and local policies can contribute to achieving this goal according to Plepys et al. (in this volume). However, there is a need for policy measures specifically focused on S.PSS, which are capable of directly influencing companies' strategies. Linked to this point, it appears that developing quantitative approaches to measure the extent to which policy measures affect companies in adopting S.PSS-oriented business strategies is crucial.

The editorial team of this SV invites suggestions and feedback on ways to build upon its contents to find, develop and implement ways to mainstream more S.PSS systems throughout the world. That process must be documented and monitored regarding the quantitative and qualitative consequences of more widespread implementation of S.PSS.

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[13] The editorial team sees this new paradigm as a shift towards a learning-by-sharing mechanism with an open and copy-left ethos: an approach that has been adopted by the two above-mentioned EU-funded research projects (LeNS 2007-2010; LeNSes 2013-2016) and has led to a multi-polar, worldwide network of networks of HEIs. (The network has developed and is promoting an O*pen Learning E-Platform* (www.lens.polimi.it); www.lenses.polimi.it), which is freely accessible by any design teacher worldwide, allowing download, reuse, remix and adaptation of its learning resources and tools on design for sustainability focused on S.PSS).

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