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Abstract

While Product Service Systems (PSS) are not inherently sustainable, they may form part of the mix of innovations that contribute to the development of more sustainable futures. However, whether the current trajectory of PSS research, with its emphasis on universal frameworks and standardization adequately reflects and builds upon PSS diversity revealed by case study research may be questioned. Opportunities for transition to more sustainable PSS may be lost. In response, this paper draws on sustainable architecture to propose fluid transitions to more sustainable PSS: to PSS design practices that embrace diversity and enable specific PSS to be developed which address contextual interpretations of sustainability challenges. The core ideas of the PSS design are critically engaged in light of the principles and priorities of fluid transitions. Research directions to support fluid transitions to more sustainable PSS design practices are then explicated.

Key words
Product Service Systems, Diversity, Fluidity

1. Introduction

While for many years design was viewed as one of the root causes of unsustainable patterns of production and consumption, today design for sustainability is thought to offer considerable utility in transitions to more sustainable futures (Thorpe, 2010). With origins in industrial design, initial work in this field focused on helping manufacturing firms meet new environmental regulations by improving the environmental performance of products (Roy, 2000). Subsequently, the need to attain greater improvements in environmental performance, led to the development of life cycle or eco-design theory and practice. These approaches aim to reduce and balance the environmental impacts of products, often with reference to material and energy reduction in particular, across a product's lifecycle: extraction, manufacturing, use and disposal phases *ibid.* Limits to this somewhat techno-centric approach such as rebound effects, increases in demand induced by resource efficient products that cancel out environmental gains (Berkhout, 2002), stimulated research to explore the meaning and role of products in society (*cf.* Walker, 2006; Ehrenfeld, 2008; Chapman, 2009; Thorpe, 2010). New insights have been sought on how products contribute to material culture and sustainable design responses developed in light of these, e.g. the design of emotionally durable products (Chapman, 2009).

So today much of sustainable design still focuses on products, closely associated actors and processes. However, broader observations of changes in patterns of consumption and production has led to the emergence of service innovations as an equally valid focus for sustainable design (*cf.* Dewberry et al., 2013). Research shows a number of firms now use their products as a foundation for service offerings. In some instances, firms add services to their products, such as extended warrantees to household appliances and repair and maintenance services to vehicles (Stahel, 2006; Gaiardelli et al., 2014). Perhaps more radically, other manufacturers have developed performance orientated service innovations which are based on their products but also potential substitutes for these, e.g. document handling services provided by manufacturers of photocopiers (Stahel, 2006). Similarly, many pesticide and herbicide producers no longer only provide chemicals but integrated crop management services too (Bartolomeo et al., 2003). In utility sectors, energy service companies (ESCOs) supply a range of services to housing developments to meet requirements for thermal comfort and hot water (Steinberger et al., 2009; Ceschin, 2013).

Such design strategies often involve examining the functionality of products in various contexts and proposing alternate service orientated means which use fewer resources to satisfy demand for such functionality (Roy, 2000; Maxwell et al., 2006; Geum and Park, 2011). For example, considering the functionality of answerphones and proposing alternative services such as voicemail. There are various definitions of such services including: eco-efficient producer services (Zaring et al., 2001), eco-efficient services (Hockerts,1999; Meijkamp, 2000; Brezet et al., 2001), eco-services (Beherendt et al., 2003) and product service systems (PSS) (Goedkoop et al., 1999; Tischner et al, 2002; Mont, 2004). The latter term is used extensively in literature. PSS are understood to comprise both products and services, which are combined to provide units of service which satisfy customer requirements for functionality. A number of PSS definitions can be found in literature, for example:

"A system of products, services, networks or actors and supporting infrastructure that is developed to be competitive, satisfy customers and be more environmentally sound than traditional business models" (Mont, 2004).

The origins of PSS lie within the resource efficiency or so called factor four discourse (Mont and Emtairah, 2008). This discourse proposes that gains in resource productivity, perhaps most notably factor four, can be achieved through market mechanisms and are necessary to help move society toward more sustainable futures. A number of PSS types have been elaborated to demonstrate in theory at least the potential of PSS to improve resource efficiency in both intermediate and final markets. A common categorisation of PSS types is used in literature (*cf.* Hockerts and Weaver, 2002; Tukker, 2004; Mont, 2004; Baines et al., 2007; Cook et al., 2012; Ceschin, 2013; Armstrong et al., 2014):

Product Orientated PSS: ownership of the product (material artefact) is transferred to customers and services are provided to help ensure product performance over a given period of time. Examples include maintenance contracts and warranties.

Use orientated PSS: ownership rights related to the product are retained by the service provider (who may or may not have manufactured it) and the customer purchases use of the product over a specified period of time. Examples include, sharing/ pooling, renting and leasing.

Result orientated PSS: similar to use orientated PSS, the product required for service delivery is owned by the service provider (who may or may not have manufactured it). However, in contrast to use orientated PSS the customer purchases an outcome/ result of service provision, which is specified in terms of *performance* not in terms of product use over a period of time. For example, instead of renting a washing machine, households access a laundry service to clean clothes and linen.

Initial research suggested that the PSS types could attain between factor four and even twenty improvements in resource productivity (*cf.* Hockerts, 1999). Thus a considerable research effort was undertaken to investigate PSS performance. Services in various contexts that map onto the PSS types as well as PSS which had been deliberately designed to improve resource productivity were evaluated. The results of evaluations showed that product and use orientated PSS were unlikely to yield improvements in resource productivity commensurate with initial predictions but that result orientated PSS still held significant potential in this regard (Tukker and Tischner, 2006). A review was also written by Tukker and Tischner, 2006) which was quite critical of sustainability focused PSS research. In summary, the main points of this review include (Tukker, 2013):

- Evaluations showed PSS had not been widely implemented. However, driven by normative sustainability requirements, case study research did not provide requisite insights on reasons for low implementation rates, such as lack of business and/ or consumer interest *ibid*.

- Several challenges associated with the methods deployed in initial research were highlighted. "There was too much concentration on individual case studies and conceptual development, and no rigorous quantitative or statistical analysis of a large numbers of cases" *ibid*. Further, it was suggested that the diversity of cases, which for example included services in business and consumer markets, blurred the scope of the PSS concept (Mont and Tukker, 2006)

- "The sustainability orientated PSS research community paid only limited attention to business management literature" (Tukker, 2014).

Recommendations were outlined to address these challenges (Tukker and Tischner, 2006; Mont and Tukker, 2006). Salient recommendations included to decentre design researchers in the PSS research community and enrol those from business, consumer and system innovation studies to it in order to better understand business interests and consumer preferences. As the PSS field was predominately based on case study research that reflected isolated concepts, it was also suggested that research could be undertaken involving rigorous cross case analyses using statistical techniques. Also, inspired by environmental management frameworks developed by the International Standards Organisation (ISO), recommendations were made to identify abstract design principles and sector guidelines to promote the uptake of service design for sustainability concepts (e.g. PSS), methods and tools (Mont and Tukker, 2006).

Since publication of the PSS evaluations and associated recommendations in 2006, research in the PSS field has proceeded in various directions and publication rates continue at a considerable rate (Tukker, 2014). Case study remains the main research method deployed in the field. However, in line with recommendations, PSS is now well established in various disciplinary areas including information systems, business management, engineering and design (Boehm and Thomas, 2013). As each of these tends to have its own focus and vocabulary, the PSS field is now more complex although there may be less chance of blind spots occurring (Tukker, 2014).

The relationship between PSS and environmental performance of production and consumption has received markedly less attention since the evaluations were published. Sustainability within the PSS field is by and large still associated with resource efficiency and life cycle assessment (Aurich 2006a; Tukker, 2014). However, there has been significant work on how PSS perform as a business concept and may contribute to competitiveness (*cf.* Neeley, 2009). Further, the challenge of developing requisite capabilities to develop and implement PSS has also been of interest (*cf.* Baines et al 2009).

While the PSS definition developed by Mont (2004) and detailed above continues to be used in various studies (*cf.* Cook, 2012), alternate PSS definitions (*cf.* Berkovich et al., 2011) as well as similar concepts continue to be generated, e.g. Integrated Product Service Systems (iPSS) (Zhang et al., 2012). Drawing on Zarvic et al. (2012), Boehm and Thomas (2013) argue that clear definitions are important in every disciplinary area and form the starting point for future research and note that this has been difficult in the PSS field as there is no unified and widely accepted definition of PSS. In response they use a graphical research method to develop the following definition: *A product service system (PSS) is an integrated bundle of products and services which aims at creating customer utility and generating value* (Boehm and Thomas, 2013).

Similarly, the PSS typology which differentiates product, use and result orientated PSS is still used in a number of studies (*cf.* Baines et al., 2007; Cook et al., 2012; Ceschin, 2012; Armstrong et al., 2014). However, a number of new PSS classifications and typologies have been proposed. For example, Ostaeyen et al. (2013) critique the established typology as it does not sufficiently capture the multiple and nuanced differences between different PSS options and practices. In response the authors propose an alternate typology based on functionality rather than changes in property rights. In addition, Gaiardelli et al (2014) propose a systematic representation of traditional and green product systems that firms can use to make sense of, structure and develop their portfolios. Further, since publication of the evaluations a number of PSS design methods have also been developed. These often focus on the relationships between the various elements of PSS such as products and services PSS (*cf.* Aurich 2006b;

Geum and Park, 2011). PSS engineering design and assessment methods have also emerged (*cf.* Sakao and Shimomuram, 2007).

Although PSS literature is expanding at a considerable rate (Tukker, 2014), there is concern that PSS are still not been widely implemented and diffused (Vezzoli et al., 2012). One reason for this may be that little attention has been given to understanding how the process of PSS introduction and diffusion takes place and how it may be managed and orientated (Tukker and Tischner, 2006, Baines et al., 2007; Ceschin, 2012). In this regard, a useful contribution has been made by Ceschin, 2012 who draws on notions of transition management and strategic niche management from innovations studies to formulate a conceptual framework to account for PSS implementation. However, with some exceptions (Cook et al., 2006; 2012), little *explicit* attention has been given to how the body of PSS knowledge developed in literature may support transition to more sustainable PSS and thereby help address implementation and diffusion challenges.

Research in the PSS field emphasizes the need to gather knowledge around common definitions and classification frameworks which can be widely applied (*cf.* Mont and Tukker, 2006; Vasantha et al., 2012; Tukker, 2014). Indeed, standardization of approaches is currently proposed, partly to move PSS research beyond a pre-paradigmatic stage (Tukker, 2014). With respect to PSS development and implementation, the logic of these recommendations is founded on the view that transition to more sustainable PSS can be supported by context independent knowledge embodied in PSS design concepts, methods and tools. While this approach to PSS research can be productive, since among other things standardisation can help attain economies of scale, it may be problematic if it is the only one underpinning PSS research.

Although there have been few attempts to link cases (Tukker, 2014), case study research continues to be one the main methods deployed in the PSS field. Case study research has revealed and continues to reveal diverse PSS designs and practices, each embedded in their own trajectories, logics and institutional arenas. Examples include, organic vegetable box delivery schemes, energy services which provide hot water, air conditioning services that involve the sale of 'coolth', luxury yacht hire, ski rental, bicycle sharing schemes, car rental services (Halme et al., 2008; Williams, 2010; Meroni and Sangiorgi, 2012). The utility of the established PSS typology to capture the full range of PSS has been questioned (*cf.* Ostaeyen et al., 2013). Indeed, context independent, tightly defined concepts, methods and tools may be difficult to develop and ineffective when faced with such diversity. A singular PSS concept which may be used in all instances may be so general that it is devoid of meaning. This matters. For diverse service offerings which may not accord with PSS concepts, definitions and types embodied in design principles, guidelines and methods, may provide multiple opportunities for transition to more sustainable futures. And these may be lost if the current research logic is not complemented by other approaches which embrace and perpetuate the diversity of PSS examples, concepts, methods and tools which can be found in literature and enable designers and other actors to productively engage in diverse PSS design and production.

To address this concern, inspired by sustainable architecture this paper proposes an alternate logic for research to support the development of PSS research: fluid transitions to more sustainable PSS. This aims to recognise and build upon diversity of PSS examples revealed by case study research, concepts methods and tools in the PSS literature to realise the multiple opportunities these may provide to attain more sustainable futures. A fluid approach to transitions to more sustainable PSS and suggested research directions to support this are the subject of the remainder of the paper. In the next section, the principles and

priorities of the fluid approach are elaborated. The core ideas of PSS are critically engaged in light of these and alternate research directions suggested to support fluid transitions to diverse PSS design practices suggested. Conclusions which not only reflect upon PSS design in the context of sustainability but also the utility of the fluid approach in a field other than sustainable architecture are presented in the last section.

2. Principles and Priorities of Fluid Transitions

The idea that sustainable development involves transition to alternate states and practices is widely accepted (Smith et al., 2010). A number of explanatory frameworks such as the multi level perspective and the practice approach have been elaborated to provide insights on sustainability transitions and identify actions that may be undertaken to manage and guide them (Pantzar and Shove, 2010; Geels, 2011).

The fluid approach to transitions was coined in sustainable architecture. Similar to the PSS field, research on sustainable architecture has revealed diverse concepts, methods and outcomes (Guy and Moore, 2005). Indeed, it has been difficult within this field to categorise buildings according to particular ideologies; develop general theories of sustainable architecture that account for the design, development and use of architectural artefacts such as buildings; develop meaningful best practice exemplars of sustainable architecture that reflect technical performances (e.g. low carbon) and images of sustainability (e.g. dark and light green) and thus; develop design concepts, methods and tools which can be broadly applied (Guy, 2011). In other words, it has been difficult to pursue a positivistic research agenda that tightly defines sustainable architecture and associated best practice (Guy and Farmer, 2001).

The fluid approach was coined in response to these challenges (Guy, 2011). It emphasises design in transitions and builds on Guy's earlier work rooted in interpretive social science, which suggests that there are multiple pathways toward more sustainable futures (Guy, Evans and Marvin 2005), multiple competing logics which underpin sustainable architecture (Guy and Farmer, 2001; Farmer and Guy, 2005) multiple sustainable architectures in Europe and North America which may be critically engaged in the absence of a framework that fixes environmental problems and responses (Guy and Moore, 2005). In summary, this work convincingly argues that:

"Debates about sustainable architecture are shaped by different social interests, based on different interpretations of the problem, and characterised by quite different pathways toward a range of sustainable futures" (Guy and Farmer, 2001)

Seen this way, in contrast to positivistic approaches which aim to fix best practice, both nature and science are cultural constructs which points toward the need for an inter-disciplinary perspective that emphasizes co-construction - of nature, culture, society, technology, place and the future (Guy and Moore, 2005). Sustainability is more a matter of local interpretation than of the setting of objective or universal goals (Guy, 2011). Thus the fluid approach questions and resists calls to define best practice which fixes environmental problems and strategies to resolve these. It provides a way of thinking about how research can support transition to design practices and outcomes that embrace and build upon design diversity. Since both research into sustainable architecture and PSS reveal a diversity of approaches which make it difficult to define best practice and universal concepts and methods, the fluid approach would seem to provide useful

insights on how to approach transitions to more sustainable PSS and address implementation and diffusion challenges.

The fluid approach conceptualises transitions as messy, contingent and difficult to separate from their contexts, which are far from benign and play a key role in transitions (Guy, 2011). It does not therefore, provide a singular pathway toward a context independent PSS design orthodoxy which may be essentialised in frameworks, blueprints, typologies and exemplars. Rather, drawing on the work of among others Castree (2005) and Massey (2005), fluid transitions should enable the many different competing definitions and interpretations of sustainability and multiple performance requirements to which PSS might respond to be recognised. Seen in this way, the practical effectiveness of PSS in responding to context specific articulations matters more than conformance with PSS types, associated best practice and exemplars. Far from problematic, the fluid approach suggests that PSS diversity provides multiple opportunities for transition to more sustainable futures. Thus rather than blur the scope of the PSS concept, the diversity of PSS, design practices, methods and contexts revealed by case study research should be embraced (even celebrated) and built upon through PSS design.

A number of general principles and priorities of the fluid approach have been outlined (Guy, 2011) and include: *First*, a flexibility to a range of technological options. *Second,* a frame to give shape to fluidity. *Third,* a commitment to pragmatism. *Fourth,* a participatory approach to design in which various voices are heard and make a difference. These constitute the 'ingredients' of a fluid strategy capable of meeting the challenges of a more complex sustainability agenda that engages environmental futures in the round *ibid* . Below, the general principles and priorities of the fluid approach to transitions approach are set out. The central ideas of PSS design are reviewed in light of these and alternate research directions to support fluid transitions to more sustainable PSS identified. In the interests of brevity and since PSS implementation in household markets is viewed as particularly challenging (*cf.* Catulli, 2012; Armstrong et al., 2014; Tukker, 2014), the sections below focus on PSS design for household consumption.

2.1 Flexibility to a range of technological options

The first aspect of the fluid approach draws on the notion of interpretive flexibility from STS (Bijker, 1997). Interpretive flexibility recognises that while there are often several competing designs with which to achieve similar objectives, there is often no decisive technical reason to choose one over another (Feenberg, 1999). This aspect of the fluid approach therefore highlights the malleability or fluidity of technology: that things can often be designed and used differently. Of course, the fluid approach does not argue that attempts to evaluate technologies should be avoided. Rather, critical pluralism is required which does not establish best practice but enables various competing designs to be evaluated according to their own logics (Guy and Moore, 2005) This means that evaluative processes should not be closed down prematurely, actors should be encouraged to look beyond contested league tables of materials, forms and locations and be open to heterogenous combinations of purpose, programme and assessment methods (Guy, 2011).

The purpose, programme and assessment methods underpinning much of PSS design focuses on the following:

- purpose – to satisfy demand using fewer resources than traditional product focused approaches (*cf.* Geum and Park, 2011)

- programme – examining the functionality of products in various contexts and proposing alternate service orientated means to provide such functionality (*cf.* Roy, 2000)

- assessment methods –are influenced by sustainable design therefore include various lifecycle analyses (*cf.* Geum and Park, 2011)

However, interpretive flexibility calls for PSS design to be open to alternative, possibly heterogenous combinations of purpose, programme and assessment methods. For example, while gains in resource productivity are important they may not be the *only* purpose of PSS design. Indeed, the utility of PSS design to attain a range of alternate sustainability/ social performances may be usefully investigated. The contribution of PSS design to, for example, urban resilience is considered in section 2.3. However, a number of different perspectives which may lead to perhaps more rounded purposes and programmes for PSS design are suggested below.

First, PSS broaden the scope of sustainable design practices: from products (material artefacts) to combinations of products and services. However, PSS also define customer value in terms of outcomes, e.g. service and functionality (Maxwell et al., 2006; Geum and Park, 2011; Ostaeyen et al., 2013). This outcome focused logic shades off the value associated with the means to attain these. It is widely accepted that products are not only of instrumental value to households (Douglas and Isherwood, 1979). Therefore in some contexts, outcomes such as functionality and service may be highly valued, while in others, other aspects of PSS may also be of value to households. PSS comprise products, services and often human actors, which individually and collectively are likely to embody a variety of meanings and values in addition to the functionality and service they provide when performing a PSS. For example, it has been shown that facilities management service contracts sometimes require new products to be used to support service delivery (Gottberg et al., 2010). While the outcomes of service delivery are specified in such contracts, the need to purchase new products suggests that the aesthetics of products used may also be important and valued by customers.

Second, while PSS design is sometimes thought of as 'beyond products' and/ or a 'shift from product to services', PSS are typically supported by a main product: a white good to which an extended warrantee is added; a car which is shared or leased; a gas turbine which provides power; a truck which provides hours of trucking. Here a preference for high or low tech products cannot be found in literature. However, the central logic of PSS suggests that other product characteristics are important; namely, durability and efficiency. In PSS, these characteristics are attained through an institutional logic. Rather than transfer ownership rights of products to the customer at the point of sale, in use and result orientated PSS these are retained by service providers, i.e. there is an institutional change. In theory this gives profit motivated firms an interest in avoiding the costs associated with the operation, maintenance, repair and disposal of products used to support PSS; it incentivises producers to develop (if they are a manufacturer) or select (if they are a service provider) more durable and efficient products to support their PSS (*cf.* Tukker, 2014). However, the limitations of this logic for product development and selection are manifold. For example, if gains in resource productivity are required, durable products do not always provide a means to attain this goal as alternate more efficient products may be developed during a 'durable' product's life (Cooper, 2005). Thus limitations to this institutional logic, which lies at the heart of PSS design, should

be explored and alternate product development and selection strategies considered.

Lastly, PSS design and implementation strategies tend to focus on the substitution of PSS for products. However, perhaps this is only one of a number of PSS design programmes which may be pursued. PSS might complement other forms of production and consumption, e.g. households may own a small car but hire a larger one to go on long journeys. Also, rather than substitute products, PSS may substitute combinations of products and services. For example, ESCOs substitute traditional utility services provided directly to households and a number of products formerly owned by homeowners, e.g. energy conversion equipment such boilers (Steinberger et al., 2009). Evaluative processes could therefore be usefully extended to include collections of entities other than those that accord with the PSS types (*cf.* Ostaeyen et al., (2013). However, the utility of PSS essentialised in a typology may be limited given the diversity of offerings which may be found or subsequently emerge in the field. Instead, context specific ensembles of heterogenous products and services that form the basis of a PSS but do not accord with the PSS types may be equally valid and form the focus of purpose, programme and evaluative processes.

2.2 A frame to give shape to fluidity

The next aspect of the fluid approach is a frame to give shape to fluidity. Frames can be thought of as something that provides *"conceptual coherence, a direction for action, a basis for persuasion, and a framework for the collection and analysis of data"* (Rein and Schon, 1994). Thus a frame focuses attention, guides research and guards against 'anything goes' (Guy, 2011).

The fluid approach is founded on the view that environmental challenges and design responses are socially constructed (Guy and Moore, 2005). Seen in this way, sustainability is more a matter of local interpretation *ibid* and does not fall evenly across space (Castree, 2005 cited in Guy, 2011). Thus context (e.g. geographical, cultural) is difficult to ignore in transitions to more sustainable PSS. Situatedness has been highlighted as a frame to shape fluidity in sustainable architecture (Guy, 2011). In this field, designs and design practices are not understood to be situated in a Euclidean spatial container comprising 'fixed' spatial entities such as cities, towns, regions and local areas that are essentialised by their cultural/ physical characteristics. Instead, drawing on relational geography (Massey, 2005), situatedness is used to recognise the value of specific solutions to contextually defined challenges, which may be diverse and include comfort, community, energy security, emergence shelter and flood protection (Guy, 2011).

PSS comprise elements which are spatially distributed. For example, a PSS which provides clean clothes and linen comprises elements such as households and laundries that are distributed in space. The need to transport clothing and linen between households and laundries as well as the resources used for such activity and consequent environmental impacts have been explored in PSS design (*cf.* Gottberg et al., 2010). However, here space is imagined as a latent surface to be 'travelled over'; conceived in terms of distances that need to be travelled across on a map. Contextual differences such as interpretations and articulations of sustainability to which PSS have been developed in response are not explicitly recognised. Thus while space is recognised in the PSS field, situatedness introduces an alternate conception of space which may reframe PSS design and open the field to a range of new possibilities. For example, rather than seek gains in resource productivity in all contexts via PSS essentialised in the types, situatedness requires this outcome to be recognised as one of a number which

may be sought in various contexts. PSS design shifts from an emphasis on universal outcomes (such as improved resource productivity (*cf.* Tukker, 2014)) to one seeking situationally specific solutions (PSS) developed in response to contextually defined challenges. This may involve seeking gains in resource productivity as well as other outcomes such as a consistent supply of local food (Halme et al., 2008).

Massey (2005) notes that neither space nor time should be considered in isolation. Therefore situatedness also involves recognising that PSS are not only situated in space but also in time. Thus PSS design may not only need to respond to sustainability demands as they vary across space but also to these as they vary in time. Since life cycle analysis (LCA) is deployed to evaluate PSS and inform PSS design, time is by and large, conceived within the field as a product lifecycle (*cf.* Aurich et al., 2006). But how PSS change over time in response to new demands as they are articulated has not been given much attention. Instead PSS are often treated as static products which are the outcome of professional design processes (i.e. as snapshots) in a slice of time: t=0. Many products are not locked down, closed and finished at the point of sale/ consumption. Rather they are redesigned to varying degrees in the so called use phase of their lifecycle. Thus it may be useful to complement current notions of PSS with one which focuses on *how PSS become in particular situations over time.* Seen in this way, PSS may be little more than temporary fixes in ongoing flows and circulations of actors and material artefacts (products) in so called consumption junctions (e.g. kitchens, offices): performances staged in different contexts. PSS may be poorly aligned with contextually defined challenges when they are first introduced but may be redeveloped by users and other actors over time in order to better align with new challenges as they emerge.

Situatedness may also hold considerable utility as a frame for PSS design since while rarely explicitly stated, PSS are quasi evolutionary. PSS design in the context of sustainability was developed in response to the emergence of modern trends in service provision which were thought to provide opportunities, to improve resource productivity, which could be realized through eco-design (Dewberry et al., 2013). However, research suggests that trajectories of service innovations have emerged in some contexts (e.g. in manufacturing sectors (Cook et al., 2006)) but not in others (e.g. in the UK construction sector (Brady et al., 2005)); the emergence of service innovations is not a peculiarly late C20 phenomenon (Bryson et al., 2004). Thus the emergence of service innovations and opportunities to address environmental issues that these may provide, is uneven in time and space, i.e. far from universal. Thus situatedness usefully highlights that some contexts may be more amenable to PSS design than others. Successful PSS design is likely to involve a focus on specific solutions to context specific challenges.

2.3 Pragmatism

The third aspect of the fluid approach is a call for pragmatism. Here drawing on Rorty (1999), pragmatism challenges the idea that singular context independent theoretical frames and solutions can be developed and applied universally to tackle challenges such as climate change. In the context of transitions, pragmatism argues against predefined purposes, programmes and assessment strategies (Guy and Moore, 2005). It suggests that a predisposition to substitute PSS types for products to improve resource productivity should be avoided. Instead, PSS design needs to be more open to addressing alternate outcomes, which are the contextual interpretations of sustainability. For example, the need

to maintain and improve urban resilience is an important public policy priority in several major cities (Newman and Jennings, 2008).

Urban resilience can be understood as the ability of an urban area to maintain structure and functionality when faced with changes in its external environment (Folke et al., 2003): in underlying environmental conditions such as precipitation and temperature as well as extreme events such as flooding and heat waves. Strategies to maintain and increase urban resilience often focus on how the risk of collapse and failure which may arise from external changes can be avoided; how functionalities such as mobility and shelter can be maintained when external changes and even shocks arise (Gunderson et al., 1995). Diversity is often promoted to address these issues *ibid*. In biological systems, diversity provides functional redundancy: if one species declines, others that provide the same functionality may continue to function. The presence of diversity is therefore important since it can buffer the impact of changes in external environments. Perhaps the central lesson of the resilience discourse is that efforts (such as sustainable design and innovation) to optimise a system to one specific set of stable environmental conditions should be avoided, as they will reduce its ability to adapt when these conditions change (Folke et al., 2003). Promotion of mono-specific technologies may be unsustainable in the face of external shocks. Diverse technologies, products and services are needed to maintain structure and functionality.

In contexts where urban resilience is sought, PSS design may contribute to diversity (Manzini 2012). For example, PSS may be produced which provide similar functionally to products but complement as opposed to replace these. Such functional overlaps may mean that functionalities can be maintained when an urban area is faced with exogenous shocks. Thus PSS may not necessarily be superior to products in all instances. PSS design strategies which favour the substitution of PSS for products should be questioned.

Also, far from blurring the scope of the PSS concept, diverse PSS, may also be actively sought to increase redundancy. These may differ in structure (actors involved in provision) and form (products/ technologies used) but provide overlapping functionality to other PSS. Seen in this way, PSS design may usefully engage in *spaces* and *places;* pragmatically build on what's going on in these to maintain and increase resilience and; develop responses in pursuit of other outcomes as necessary. The point here is not that PSS design to promote resource efficiency is wrong or that urban resilience is the right outcome. Rather a plurality of outcomes which include resource efficiency and urban resilience may be found in various contexts. Indeed, these and other outcomes are likely to vary across space and time. Research is needed to support development of PSS design practices that pragmatically engage with communities to develop specific PSS that respond to these requirements.

2.4 Participatory approach to design in which various voices are heard and make a difference

Finally, the fourth aspect of the fluid approach calls for a participative approach to design through which voices beyond traditional constituencies may be heard and make a difference (Guy, 2011). Within the PSS field, considerable emphasis post 2006 has been placed on developing the research community to encompass disciplines other than sustainable design (Boehm and Thomas, 2013; Tukker, 2014). Since PSS design is principally a supply side solution to environmental problems, there is a strong emphasis on producers in research, e.g. firms (*cf.* Baines et al., 2007). One of the principal environmental benefits postulated of PSS is that producer responsibility is extended over the lifecycle of products that

form the basis of these (*cf.* White et al., 1999). More broadly, one may gain a sense from PSS research that firms are better able and willing to manage products than other actors such as households. The validity of this view may be usefully explored in subsequent research. Whether firms should own and control products which are central to the means of household production may perhaps also be debated.

Here the fourth aspect of the fluid approach calls for PSS design practices which seek to identify, hear and respond not only the voices of 'experts' and producers, but actors such as consumers and householders too. In addition to a general sensibility for participation in civil society, there may also be practical reasons to include consumers and households in PSS design: since the potential outcomes of PSS, such as gains in resource productivity, may be dependent upon their behaviour. Research shows that household's choice, use and management of products that complement PSS influences their environmental performance (Gottberg et al., 2010). Thus ways to engage a broader constituency of actors in PSS design need to be found. Here the answers may not only lie with marketers and those interested in consumer science. Studies of consumer culture rooted in anthropology may also provide useful insights (*cf.* Mylan, 2014). For example, PSS design could be framed as a distributed competence not merely conceptualised as the preserve of the 'professional expert' designer. Seen in this way, professional designers would be one actor involved in the co-creation of value. Professional designers might help stimulate, among other actors, awareness of possibilities for PSS design and generate material resources and contexts from which new and valued PSS might emerge. Thus rather than de-centre designers (Mont and Tukker, 2006), alternate research might reframe their role in PSS design: to one which enables various voices to be heard and make a difference.

3. Summary and Conclusions

In response to the emergence of an implementation gap, this paper advocates a fluid approach to transitions to more sustainable PSS. The main ideas of PSS research were critically reviewed in light of the principles and priorities of fluid transitions in the preceding sections. Alternate research pathways were proposed that may enable the multiple opportunities that diversity may provide for transition to more sustainable PSS to be realised. In summary, fluid transitions to more sustainable PSS should involve:

- alternate purposes, programmes and assessments that for example, recognise not only the functionality of products and PSS but also their social meanings

- situatedness as a frame to shape fluid transitions to PSS design practices that respond to changes in context, as they vary in both time and space.

- a commitment to pragmatism in order to enable PSS design to deal with the challenges at hand, such as to attain context specific outcomes such as urban resilience.

- greater participation in PSS design, in which actors that lie beyond the epistemic community have their voices heard and make a difference.

However, the above should not be simply taken as a blueprint for PSS implementation and associated research. Rather, the usefulness/ validity of these will only be determined as the links between research, design practices and contextually defined sustainability challenges are further developed. In this way, fluid transitions should 'open up' the field to a multiplicity of ways of

thinking about PSS, their design and development, which recognise that PSS design cannot be easily closed and locked down, disciplined around typologies and predefined outcomes, such as resource-efficiency.

Importantly, this paper not only makes a contribution to PSS design research but demonstrates the applicability of the fluid transitions approach in fields other than sustainable architecture. For example, it shows that situatedness provides the basis of a useful frame to shape fluidity in both sustainable architecture and PSS design. As highlighted in section 2.2 research may be usefully pursued which does not conceive PSS as the static outcome of professional design processes but rather as a flow of practices which form part of ongoing circulations of human and non-human actors, which designers and other actors are part of, which may be 'sustainable' in some spaces and times and perhaps not in others. However, there are likely to be limits to fluidity. Bijker (1997) notes that obduracy limits our politics and by extension may limit or shape fluidity. For example, the obduracy of what constitutes 'good' service delivery embodied in conventions and/ or formal contractual agreements may be particularly difficult to change and play a key role in shaping PSS design in various contexts (*cf.* Gottberg et al., 2010). Equally, since PSS require various inputs (e.g. for energy, water) from utilities, the obduracy of various infrastructures may also have similar shaping effects.

Furthermore, while the principles and priorities of the fluid approach have been set out by Guy (2011), they suggest *what* should be attended to in transitions (e.g. participation), but provide few details of *how* fluid transitions to more sustainable PSS might be stimulated and attained. With respect to fluid transitions to more sustainable PSS, research is required to investigate how designers might *know* contexts in which PSS might be developed and how to engage with these to help identify interpretations of sustainability and potential PSS responses to these; may *identify* actors that lie beyond the traditional nexus in the field; may *know* what's going on in contexts and *contribute* to the challenges at hand deemed to be important in these. Clearly a recipe book is not required, as in many ways that would contradict the fluid approach. Rather a multiplicity of ways of knowing may be usefully collected that may involve data collection via film, poetry and prose and prototyping PSS designs.

In no way is this paper a definitive statement of fluid transitions to more sustainable PSS. Rather its aims are modest: to provide a thought provoking first step along a path toward such an approach and a platform of knowledge for this purpose. Further research is required to build upon the fluid approach outlined in this paper. Further case study research is also required to help identify the multiplicity of PSS, associated strategies and practices in the field. However, this should not necessarily involve using the results of case study research to extend the PSS types. Indeed, further strengthening a generalisable theory of PSS, however flexible, should be avoided. Rather, further research could usefully unpack (not criticise in light of a consensual sensibility for a unifying PSS theory), PSS in various contexts and associated design processes to illustrate the diversity of approaches which may be built upon and extended to address contextually defined challenges. Although the work of Meroni and Sangiorgi (2012) to explore and map seventeen Service Design case studies does not fully explore PSS concepts, it may provide a useful starting point here. Indeed, further case study research to fully explore multiple PSS is needed. By following the fluid approach from sustainable architecture, such research might enable specific PSS to be developed which respond to contextually defined challenges.

Finally and perhaps more radically, it may be better to avoid developing design practices directly associated with the PSS concept, which is based on unresolved

dualisms such as product and service and poorly articulated entities (in this context) such as system. Those interested in design for sustainability may be thought of as trend watchers who intervene in eco-systems of human and non-human (artefacts) actors that provide service and may assist in development of more sustainable futures. Seen in this way, professional designers may not play a decisive role but set the stage and provide support necessary for multiple actors to identify and meet specific outcomes which they deem to be useful and credible. Such approaches may have a better chance of success than those provided by traditional producers: as they may engage and be owned by a wider constituency of actors including users and therefore may have a better chance not only of adoption but of attaining sustainability.

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