How to facilitate the implementation and diffusion of sustainable Product-Service Systems?

Looking for synergies between strategic design and innovation sciences

Fabrizio Ceschin
Politecnico di Milano, INDACO Department, Design and system Innovation for Sustainability (DIS) unit of research, Italy

Eco-efficient Product-Service System (PSS) innovations represent a promising approach to sustainability. However the application of this concept is still very limited because eco-efficient PSS are intrinsically radical innovations, that challenge existing customers' habits (cultural barriers), companies' organizations (corporate barriers) and regulative framework (regulative barriers). Because of these multi-dimensional changes, eco-efficient PSS can be considered complex and highly uncertain innovations, and therefore difficult to be predicted, planned and managed. Therefore the challenge is not only to conceive eco-efficient PSS concepts, but also to understand which are the most effective strategies to introduce and diffuse these concepts in the market.
Bringing together insights from innovation sciences (in particular transition management, strategic niche management and radical innovation studies), the paper puts forward an approach through which effectively manage the implementation and diffusion of eco-efficient PSS innovations.
Starting from these results the paper outlines the implications on the design level. A new different role for design emerges. A role that may potentially opens new fields of activity alongside the consolidated ones. A role in which design is not only aimed at defining sustainable PSS concept but it is also aimed at promoting, facilitating and setting-up the conditions for implementing and diffusing this kind of innovations.

Eco-efficient Product-Service System (PSS) innovation: a promising approach to sustainability

It is widely shared that the transition towards sustainability will require a system discontinuity, meaning that a radical redefinition of the current structures of production and consumption is needed. In the second half of the '90s a series of studies and analyses led to a clearer understanding of the dimension of change necessary to achieve a society that is effectively and globally sustainable. These studies indicate that in 50 years, considering the raising consumption levels and the doubling of the world's population, a sustainable society should use 90% less resources than industrialised countries are doing today (Factor 10 Club, 1994; Schmidt-Bleek, 1996; WBCSD, 1996). In other words, conditions for sustainability can only be achieved by drastically reducing the consumption of environmental resources compared to the current average consumption in mature industrialised contexts.

Given the dimension of the required change it is therefore clear that innovations on a process and product level, although being fundamental and necessary, are not alone sufficient to obtain the just mentioned radical shift. In fact, although it is true that these innovations can improve environmental performances of products (by a factor of 2-4 for Charter and Tischner, 2001), it is also true that these improvements are often negatively counterbalanced by an increase in consumption levels (Haake and Jolivet, 2001). For instance, the environmental gain achieved through the improvement of car efficiency in the last 15 years (10%) has been more than offset by the increase in the number of cars and by the consequent increase (30%) in the overall number of km covered (EEA, 2008).

In addition it has to be underlined that in the traditional production and consumption model, based on the traditional sale of products, producer's economic interest usually does not converge with an environmental interest in optimizing the resources consumed (Mont, 2002; UNEP, 2002). For instance car producers are economically interested in reducing the energy and material consumption in the production phase (in order to cut down manufacturing costs), but at the same time they do not have a direct economic interest in extending a car life span as much as possible (on the contrary they are interested in accelerating the replacement in order to increase sales).

For these reasons, if we want to effectively tackle sustainability, there is a need to move from a focus on product improvements only, towards a wider systemic approach that takes in consideration new potential ways of satisfying the social demand of wellbeing. In this perspective, as suggested by Stahel (1986, 1989), we should move from an industrial economy, in which the central value is based on the exchange of products to be consumed and in which the growth is strongly linked to resources consumption, to a functional economy, in which products are mere means of providing functions. A functional economy is oriented to satisfy consumers through the delivery of functions (e.g. mobility; thermal comfort; having clean clothes) instead of products (e.g. cars; boilers and methane; washing machines and powder). Its economic objective is to create the highest possible use value for the longest possible time while consuming as few material resources and energy as possible; thus it is potentially more dematerialised than the present economy, which is focused on production and related material flows as its principal means to create wealth (Stahel, 1986; 1997). In other words a functional economy can potentially bring about a reduction in the current levels of resources consumption, without minimizing consumers' level of satisfaction (UNEP, 2002; Mont, 2004a; Tukker and Tischner, 2006a).

Within this perspective several authors consider promising to look at the concept of **Product-Service System (PSS) innovation**.

Product-Service System and sustainability: a brief overview

A PSS can be described as an integrated system of products, services and socio-economical stakeholders, designed to fulfil a specific client need (Goedkoop et al., 1999), with the word *system* referring to both the *system of products and services* delivered to the client, and the *system of actors* that produce and offer the combination of products and services.

Therefore PSS is not merely selling physical products or services (as in the traditional economic model), but offering a combination of products and services where the focus is the satisfaction of a client demand. The product/service ratio can vary in relation to the different type of PSS; three broad categories, on which several authors converge, can be identified (UNEP, 2002; Tukker, 2004; Tukker and Tischner, 2006a; Baines at al., 2008):

- *Product-oriented services*, when products are still sold, but with some additional services (e.g. maintenance, repair, up-grading, substitution and product take back);
- *Use-oriented services*, when provider owns the products and made them available to users in different modalities (e.g. leasing, sharing, pooling);
- *Result-oriented services*, when provider and customer agree on a specific final result; companies offer a customized mix of services and maintain ownership of the products; customer pays only for the provision of agreed results.

Basically, rather than the "traditional" forms of sales, ownership, consume and disposal of products, a PSS innovation is focused on delivering a particular satisfaction. PSS is not a new economic concept: in fact several examples of PSS have been implemented in the last decades by various companies (Goedkoop et al., 1999; UNEP, 2002; Mont, 2004; Vezzoli, 2007). However, the key point to be underlined (which is also the one that firstly attracted the interest of researchers on this topic), is the fact that PSS, if properly conceived, can decouple economic value from material and energy consumption. These PSS can

be defined *eco-efficient* (UNEP, 2002; Vezzoli, 2007), meaning that the economic interest of the socio-economical stakeholders involved in the PSS offer converges with an interest in optimizing the environmental resources consumption. As opposed to traditional business models, eco-efficient PSS rewards low resources consumption in use and product longevity (rather than obsolescence and high running costs). In fact, if what is offered is the fulfilment of a satisfaction (e.g. having clean cloth), less material and energy are used by the provider to deliver this satisfaction, minor will be the costs to be sustained and therefore higher the profits. Innovations on a PSS level can potentially bring to rethinking the entire production and consumption system, and therefore have significant potentials to lead to radical environmental impact reductions, as opposed to the simple redesign and improvement of existing products (Tischner, Rayn and Vezzoli, 2009).

An illustration of the potential environmental benefits of an eco-efficient PSS is clear in the "Pay-per-use" solution offered by Ariston (an Italian washing machine producer). Here, rather than selling a washing machine, Ariston provides access to it enabling clients to get their "satisfaction", i.e. "having clean cloths". The payment is based on number of washes and includes delivery of a washing machine at home (not owned by the customer), electricity supply (not directly paid by the customer), maintenance, and end-of-life collection. Within this business model Ariston is economically incentivised in reducing as much as possible the washing machine energy consumption (in order to reduce operational costs and maximise profits), and in designing and providing long lasting, reusable and recyclable washing machines (in order to postpone the disposal costs and the costs for the manufacturing of new washing machines).

In addition to potentially decouple value creation from resources consumption, PSS can also bring further benefits at a company and customer level. In fact a PSS approach may potentially allow companies to find new strategic market opportunities (Goedkoop et al., 1999; Manzini, Vezzoli and Clark, 2001; Mont, 2002). A PSS offer is indeed highly customisable (thanks to the flexibility of the service element), and therefore represents an alternative to standardization and mass production. Moreover, this increased flexibility leads companies to be able to respond more rapidly and easily to the changing market (UNEP, 2002). PSS innovations can improve companies strategic positions also because they can establish longer and stronger relationships with customers (Manzini, Vezzoli and Clark, 2001; UNEP, 2002; Mont, 2004), and because they can anticipate the implications of future environmental legislation (Mont, 2002; UNEP, 2002). From a customer point of view, a PSS can provide value through more customised offer, and therefore, given its flexibility, can better suite customer needs and is better able to respond to changing preferences (Mont, 2002; Cook, Bhamra and Lemon, 2006). In addition customer may be released from the maintenance and disposal responsibility for a product that stays under ownership of a producer for its entire life span (Mont, 2002).

In the last 15 years the European Union has dedicated special attention to this kind of innovations: a wide number of research projects in the field of PSS and sustainability have been supported by EU funding. These researches brought to clarifying the concept of PSS, understanding its characteristics, potential benefits, drivers & barriers, possible rebound effects, etc., and to developing (and partly testing) different methods and tools to orient and support the design of eco-efficient PSS. For example the *Kathalys method for sustainable product-service innovation* (Luiten, Knot, and van der Horst, 2001); *DES, Design of eco-efficient services methodology* (Brezet et al., 2001); *PSS innovation scan for industry* (Tukker and van Halen, 2003); *HiCS, Highly Customerised Solutions* (Manzini, Collina and Evans, 2004); *MEPSS, Methodology for Product Service System development* (van Halen, Vezzoli and Wimmer, 2005); *Practical guide for PSS development* (Tukker and Tischner, 2006b); *MSDS, Method for System Design for Sustainability* (Vezzoli, Ceschin and Cortesi, 2009). These methods are typically a development of more conventional product design processes, and usually are organised around five main phases: strategic analysis, exploring opportunities, PSS concept design, PSS design and engineering, implementation. A wide range of tools has been developed to support the different phases (see for example Verkuijl and Tischner, 2006). These methods can effectively support designer in developing eco-efficient PSS concepts, but they put little (or no) emphasis on the implementation phase. And this is a problem, because several barriers make the process of implementation and diffusion of these radical innovations a highly risky and uncertain one.

Eco-efficient PSS: implementation and diffusion barriers

Despite all the knowledge accumulated on understanding how to develop eco-efficient PSS, and despite their potential win-win characteristics, it has to be underlined that the application of this concept is still

very limited. The reason is that eco-efficient PSS are intrinsically radical innovations, and the adoption of such strategy bring with significant corporate, cultural and regulatory challenges:

- For *companies* the adoption of a PSS strategy is more complex to be managed than the existing way of delivering products alone. In fact there is the need to implement changes in corporate culture and organisation in order to support a more systemic innovation and service-oriented business (UNEP, 2002); there is indeed a resistance of companies to extend involvement with a product beyond point-of-sale (Stoughton et al., 1998). The extended involvement requires in fact new design and management knowledge and approaches. Moreover, since PSS determine the changing of systems and sources of gaining profit, this could deter producers from employing this concept (Mont, 2002); PSS in fact require medium-long term investments and are connected with uncertainties about cash flows (Mont, 2004). Moreover, a further obstacle is the difficulty of quantifying the savings arising from PSS in economic and environmental terms, in order to market the innovation to stakeholders both inside and outside the company, or to the company's strategic partners (UNEP, 2002).
- For *customers*, the main barrier is the cultural shift necessary to value an ownerless way of having a satisfaction fulfilled, as opposed to owning a product (Goedkoop et al., 1999; Manzini, Vezzoli and Clark, 2001; Mont, 2002; UNEP, 2002). In fact the problem is that solutions based on sharing and access contradict the dominant and well established norm of ownership (Behrendt et al., 2003); this is especially true in the B2C market, while in the B2B sector numerous examples of eco-efficient PSS concepts can be identified (Stahel, 1997). Product ownership in fact not only provides function to private users, but also status, image and a sense of control (James and Hopkinson, 2002). Another obstacle is the lack of knowledge about life cycle costs (White et al. 1999), that makes difficult for user understand the economic advantages of ownerless solutions.
- On the *regulatory side*, actual laws may not favour PSS oriented solutions. Environmental innovation is often not rewarded at the company level due to lack of internalisation of environmental impacts (Mont and Lindhqvist, 2003). In addition there are difficulties in implementing policies to create corporate drivers to facilitate the promotion and diffusion of this kind of innovations (Mont and Lindhqvist, 2003; Ceschin and Vezzoli, 2010).

Schot and Geels (2008) consider radical innovations always immature when they enter the market because they cope with a dominant socio-technical regime (and its established and stable rules and networks of actors). Eco-efficient PSS innovations are in most of the cases such a radical innovation. For this reason, for those companies that do see PSS innovation as key to their future, there are still significant challenges to be faced, not only in developing promising PSS concept, but also in adopting the best strategy to introduce and diffuse it in the market. In fact eco-efficient PSS cannot be implemented in the same way as incremental innovations (which assume the stability of technological, regulatory and market environment).

Paper purpose and research questions

Within this framework the focus of the paper is on the implementation and diffusion of eco-efficient PSS. In particular the research questions to be addressed are:

- which are the dynamics and the factors that facilitate and obstacle the implementation and diffusion of eco-efficient PSS? Which are best strategies to effectively manage the process of introduction and diffusion of this kind of innovations?
- and, which could be the role of design in supporting and orienting this process?

Bringing together insights from innovation sciences (in particular transition management, strategic niche management and radical innovation studies), the paper firstly puts forward an approach through which effectively manage the implementation and diffusion of eco-efficient PSS innovations. Based on these considerations the paper then presents and discusses the potential contribution that design can have in stimulating the implementation of eco-efficient PSS innovations.

Implementation and diffusion of eco-efficient PSS innovations: insights from innovation sciences

The challenge of understanding radical or system innovations has been examined in the *innovation sciences* field, from different perspectives:

- the *macro perspective* of transition and system innovation theorists, who focus on the dynamics that regulate shifts in dominant socio-technical regimes (see for example Geels, 2002; 2004);
- the *meso perspective* of Strategic Niche Management theorists, who focus on the level of the actors network involved in the innovation process (see for example Kemp et al. 1998; 2001);
- and the *micro perspective* of innovation management theorists, who study the dynamics of innovation from a firm point of view (see for example Lynn et al. 1996; Rice et al. 1998; 2002; Cooper, 2000).

Transition theorists refer to *system innovations* as major changes in the ways societal functions such as transportation, communication, housing and feeding are fulfilled (Rip and Kemp, 1998; Geels, 2002). System innovations are complex and long term processes that require changes in the social, economical, technological and policy domains. Through historical socio-technical case studies, transition scholars have analyzed how system innovations take place and elaborated a model, called "The multi-level perspective on transitions" (Geels, 2002; 2004) through which describe the dynamics that regulate these complex and long-term processes. The multi-level perspective distinguishes three analytical concepts:

- the *socio-technical regime* which can be defined as the dominant way of innovating, producing, distributing, consuming etc. It is made up of different socio-economical stakeholders, practices, rules and ways of doing related to a specific field (mobility, energy, etc.). The regime rules and institutions guide regime actors in a specific direction discouraging the development of alternatives.
- the *niche,* a protected space that is "isolated" from the influence of the dominant regime, where radical innovations can be tested, become more mature, and potentially replace regime practices.
- and the *landscape,* that is the relatively stable social, economic and political context in which actors interact and regimes and niches evolve. It represents the background for regimes and niches. It can influence the regime and the niches, but cannot be influenced by them (at least in short term).

Niches are a fundamental part of transitions because they act as "incubation rooms" for radical novelties (Geels, 2002), where experimentations and learning processes take place. Radical novelties always start from niches, however, while niche developments can hold great promise, they do not immediately live up to expectations because they are immature when they enter the market (Witkamp, Raven and Royakkers, 2010). In this sense, if immediately exposed to market competition, they have great probability to not survive. For this reasons Schot et al. (1996) proposed the concept of "technological niches", artificially created spaces where continuous experiments can bring them to mature. In other terms niches can be used as strategic opportunities for experimenting, learning, improve the innovation and establish new social networks in order to gain momentum for diffusion or even replace dominant regime practices (Kemp et al, 1998).

Several scholars have investigated more precisely how experiments in niche can be fostered to favour wider transition processes. This research, denominated *Strategic Niche Management (SNM),* individuated as key important three internal processes (Kemp et al, 1998; 2001; Hoogma, 2000; Hoogma et al., 2002). Firstly, the *building-up of a broad socio-economical network,* including all relevant types of actors, capable to protect and support the innovation incubation and development. Secondly, the *convergence of actors expectations into a shared visions,* in order to give strategic orientation to the innovation development. Thirdly, an *effective learning process* between the involved actors, which is recognized crucial because it enables adjustments of the niche innovation and increases chances for a successful diffusion.

Niche experiments and pilot projects are considered of key importance for stimulating transition to radical innovations even within the model of *Transition Management (TM)* (Rotmans et al. 2000; Rot-

mans and Loorbach, 2006; Loorbach, 2007). TM (that builds upon SNM), is a governance approach developed to orient and govern sustainability transitions, and currently many policy domains in the Netherlands are adopting it for stimulating transitions to a more sustainable fulfilment of a societal function such as energy and mobility (Raven, Bosch and Weterings, 2007). In TM these niche experiments are seen as a part of a much broader process. TM is in fact a cyclical and adaptive process, with each cycle consisting of four main activities (Kemp and Rotmans, 2004): establishment and development of a *transition arena;* development of *long term visions* and a shared *transition agenda*; implementation of *transition experiments and projects; monitoring, evaluating and learning*.

Also in *innovation management studies* the use of experiments is recognised to be crucial. For Laredo et al. (2002) the development of radical innovation projects cannot be explained in terms of a sequence of states (e.g. concept, pilot, prototype, industrial development) which projects are expected to go through but, rather, in terms of *trials* which projects subject themselves to in the course of progressively testing the relevance of the hypothesised innovation characteristics. It has to be underlined that these trials (or experiments), are not simply tests made within one company laboratory, but wider socio-technical experiment involving a broad range of stakeholders (e.g. a consortium including multiple companies, some interested users, a public authority, etc.). Latour (2000) defines this kind of trials as *collective experiments* or *socio-technical demonstrations*, the role of which is to test the technical, social, political and economic configuration of the innovation.

Along the same line, Brown et al. (2003) underline the importance of small scale *bounded socio-technical experiments (BSTE)* to introduce new radical technologies or services, while Lynn et al. (1996) speak about the *"probing and learning" strategy:* market try-outs with early prototypes, used as a vehicle for learning about the new technology in its real life context, followed by adjustment in technology design and marketing approach (at the same time the exposure to early prototypes influences the expectations, needs and behaviour of potential customers).

As we have seen before SNM and TM, beyond transition experiments, give strategic importance to other elements: the building up of a broad actors network, the definition of a shared long term vision, and the presence of a learning attitude in the involved stakeholders. These elements can be found (with different terms) also in *innovation management* and *sociology of innovation* studies.

Callon (1991) underlines the importance of involving "a coordinated set of heterogeneous actors - laboratories, technical research centres, financial organizations, users, and public authorities - which participate collectively in the development and diffusion of innovations, and which organize, via numerous interactions, the relationships between research and the market place". Callon (1991), Callon et al. (1992), and Laredo and Mustar (1996) refer to this set of heterogeneous actors as the "techno-economic network".

De Laat (1996) and Akrich (1992) state the importance of *scenarios* and *visions* of the future working world (in which the innovation will be used), in order to enrol actors and orient their actions. On the same line of thought van den Bosch et al. (2005) suggests that the definition of a shared *long term vision* and a *roadmap* (derived from the vision through a backcasting process) is crucial in starting transitions or system innovations.

The value of a continuous *learning process* among the actors involved in the innovation process, is transversally recognised by many authors as crucial for successful innovation (see for example Cooper, 2000; Rice et al, 2002; Jolivet et al, 2002; Brown et al, 2003). Authors underlines that learning should be broad (focusing on the different social, technological, economic, and political aspects of the innovation) and reflexive (meaning that it has to be used to adjust and adequate the innovation characteristics).

In synthesis, which factors are considered crucial for effectively incubate, manage and develop radical innovations?

Firstly, the **adoption of a dynamic and iterative approach** based on the **setting up of protected socio-technical experiments** (to be reinforced, scaled up and branched). Secondly, the presence of a **wide network of actors** capable to protect and support the innovation. Thirdly, the development of a **long term vision** to give a direction to stakeholders' actions. Fourthly, the proneness, of the stakeholders involved in the project, to continuously **evaluate the activities undertaken and learn** from them.

Critical factors for managing the implementation and diffusion of eco-efficient PSS

Innovation sciences has often focused on technological radical innovations and never referred to the specificity of eco-efficient PSS innovations (in which the technological element is often not the most important). A case study investigating the innovation journeys made by 8 companies in introducing their eco-efficient PSS concepts in the market (Ceschin, 2010), shows that the factors previously underlined are valuable also for managing the introduction and diffusion of eco-efficient PSS innovations.

The introduction and diffusion of eco-efficient PSS is of course a complex process, subjected to several variables. Thus it is not possible to define a winning recipe that can be used to manage successfully these processes. However there are approaches that can be adopted to increase the probability of success.

The first element that showed to be critical is the **implementation of socio-technical experiments.** These experiments have not to be exclusively aimed at verifying the technical and/or usability elements, but also used to: verify and favour the acceptability by the various social groups; identify barriers for a prospective implementation; identify the most suitable policy measures to be adopted to promote the innovation; and give visibility to the project (to raise interest and attract new stakeholders). In other words, we are talking of socio-technical demonstrations, aimed at learning and exploring how to gradually reinforce and scale-up the innovation (favouring its societal embedding).

For example (Ceschin, 2010) *Clear Channel Outdoor* ideated its bike sharing system in 1997; after some rejections by several municipalities, the concept was implemented as a small pilot project in the city of Renne (France). This pilot was key important because gave the opportunity to test and improve the innovation (both from a technical and social point of view), but also to involve new actors (synergies were established with the local public transport company), and to attract the interest of the user and other municipalities. In 1998 the system was scaled up in a full operational service and from 2001 replicated in 13 cities around the world.

The presence of a **wide and dynamic network of actors**, capable to support and protect the eco-efficient PSS innovation (during its incubation, experimentations, scaling-up and branching) is another element that demonstrated to be key important. A network that should involve not only the actors more tightly linked to the innovation (e.g. producer, partners and suppliers) but also other actors: for instance universities and research centres (that can give scientific support), institutions and public administrations (that can promote the innovation and give political support), and also NGOs and media (that can give visibility to the innovation). In other words it is fundamental to build-up a heterogeneous network characterized by scientific, social, economic, politic and cultural linkages.

For example in Finland, in order to foster the diffusion of *Energy Service COmpanies (ESCOs)*, a network made up of ESCOs, municipalities, financial institutions and a governmental institution, was established. Working groups and brainstorming sessions were organized in order to combine and match the needs and perspective of the different involved stakeholders, and to try to solve the implementation and diffusion barriers (for example it was decided to modify the Finnish legislation for the competition in public procurement in order to facilitate the diffusion of the ESCO concept) (Kivisaari, Lovio and Vayrynen, 2004).

In order to give a direction to the innovation development (and so to orient stakeholders actions), the building up of a **long term and shared vision** (shared between the involved stakeholders) is another factor that showed to be crucial. A shared vision that has to be capable to converge actors expectations but also to attract and involve new socio-economical stakeholders. A shared long term vision is important also because can be used as a guide to formulate short term objective and actions (and more in general to outline a **transition path** or **roadmap** for reaching the vision itself). However it has to be underlined that the vision (and consequently also the roadmap) are not fixed, but rather can be adapted and modified in time (e.g. in relation to the feedback coming from the socio-technical experimentations or from stakeholders network adjustments).

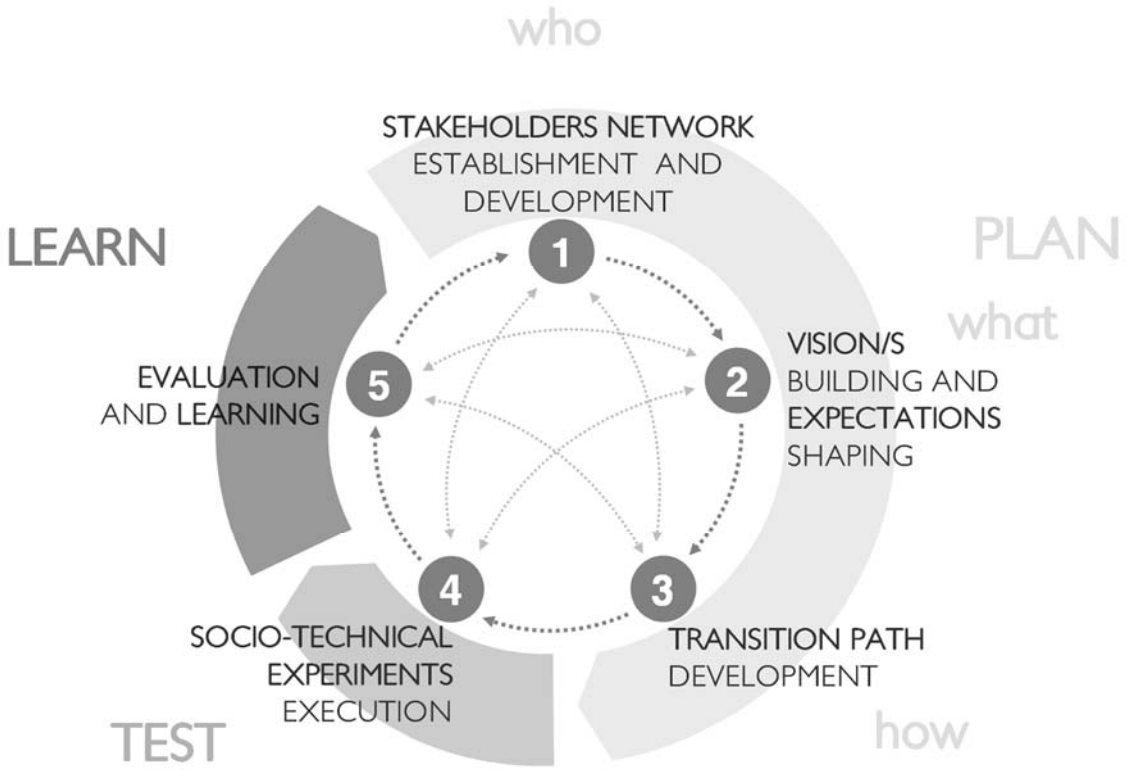
An illustration of the importance of long term visions is given by the previously mentioned *Clear Channel Outdoor* example. In this case the company ability in presenting the project vision and concept (underlining all the potential economic and environmental benefits) was fundamental in order to convince the municipality of Renne to start a pilot project. The same project vision was important to involve the local public transport company in the project.

The last key factor is the **proneness** (of the stakeholders involved in the project) to continuously **evaluate the activities undertaken and learn** from them. An effective learning process is in fact crucial for successful innovation, because it enables a continuous adjustment and refinement of the innovation characteristics. The learning process should be broad, focusing not only on the technical and economical elements of the innovation, but also on the social, regulative and cultural ones.

For example (Ceschin, 2010) *Qurrent* (a service provider on decentralized renewable energy systems), before starting the commercialization of their solutions, decided to implement seven pilot projects with the aim of testing the solutions (technical and usability aspects), understand the commercialization barriers (even the regulative and cultural ones), and explore how to solve them. The feedbacks collected are used to learn and understand the adjustments to be undertaken.

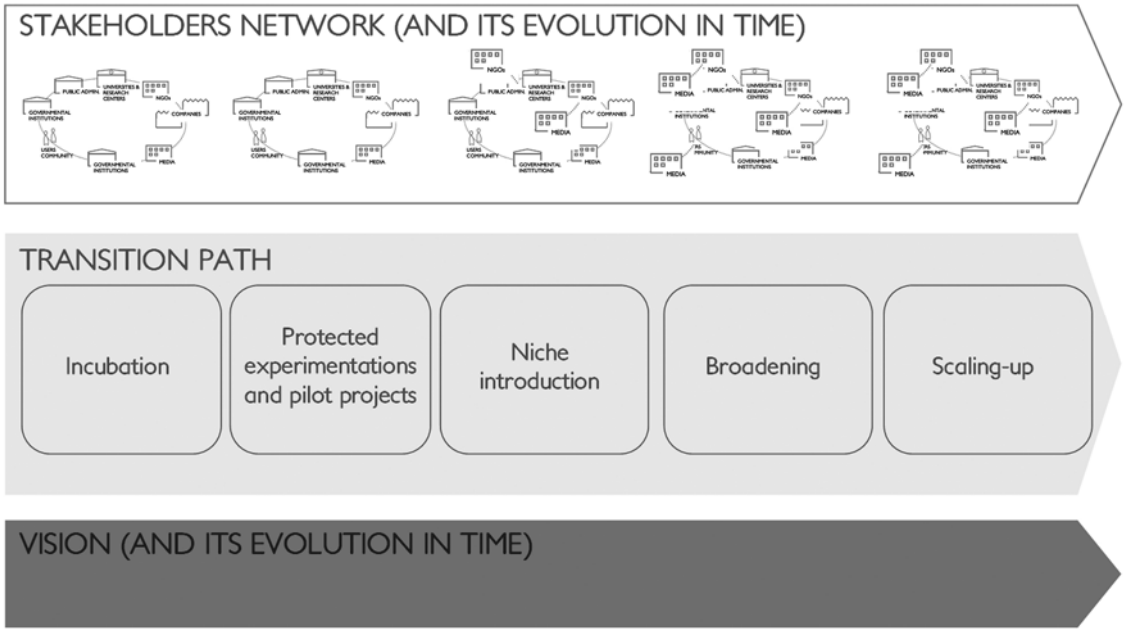
In synthesis, to effectively incubate, introduce and diffuse eco-efficient PSS, what is required is not a one-off action, but a development path based on dynamic adaptation. In other words it is not effective to implement this kind of innovations through a linear sequence of states (e.g. concept, development, prototype, industrial development, market introduction), but through a dynamic and cyclical approach, oriented towards a long term vision, and based on the setting up of socio-technical experiments (to be reinforced, scaled up and branched) and continuous learning by actors network (figure 1).

Figure 1: The cyclical and dynamic approach to introduce and diffuse eco-efficient PSS. In the first phase the stakeholders network, the long term vision and the transition path for achieving the vision itself are defined; in the second phase the innovation is tested through socio-technical experiments, which are then evaluated (third phase) and used to adjust the stakeholders network, the vision and the transition path.



If we look to what happen in time, this dynamic and cyclical process brings to (van den Bosch and Taanman, 2006): *deepening* (learning as much as possible from the experiment in a specific context), *broadening* (repeating the experiments in other different contexts), and *scaling-up* (embedding the experiments in the regime, to replace dominant practices). It is therefore a path that brings the innovation to be gradually incubated, tested in protected socio-technical experimentations, introduced in niche markets, broadened and embedded in the regime (figure 2).

Figure 2: The transition path brings the innovation to be gradually incubated, tested, introduced in niche markets, broadened and scaled-up. It is a path oriented towards a long term vision and supported by a network of actors. It is based on dynamic adaptation (the stakeholders network and the long term vision evolve in time in relation to the feedbacks coming from the transition path).



Implications on the design level: a new strategic design approach

If the previously outlined approach is promising to incubate, introduce and diffuse eco-efficient PSS, the question is: what are the implications on the design level? What could be the role of design?

We know that several methods and tools have been developed to support designers in ideating and developing eco-efficient PSS concepts (see for example the overview of different methods and tools made by see for example Verkuijl and Tischner, 2006). However, if designers want to act as effective agents of change, they have to be aware of the mechanisms and dynamics that regulate the implementation and diffusion of this kind of innovations (and how it is possible to guide and orient them). In this sense if designers want to play a more effective role in the transition towards sustainability, they cannot limit themselves to propose eco-efficient PSS concepts; in fact, since these radical innovations usually encounter the opposition of the dominant socio-technical regime, designers should also have the role to indicate the most promising pathways for the implementation and diffusion of such radical innovations.

In other words, the hypothesis is that strategic **design could have a role** not only in generating eco-efficient PSS concepts, but also **in defining transition paths** to support and facilitate the introduction and diffusion of the concept itself. In this sense designers could guide and support a company, an institution or a network of actors, in the process of introducing and gradually embed in the society radical sustainable innovations (in particular eco-efficient PSS).

If in incremental innovations usually the design phase is separated from the market introduction, when we deal with radical innovations (characterised by being highly uncertain and risky) the design activity should go in parallel with the experimentation and the commercialisation. The innovation is kept open, and continuously adjusted thanks to the feedbacks coming from the pilot projects and the first niche market introduction.

In this perspective, what has to be designed is not only the PSS concept but also the path to gradually incubate, test, introduce, broad and scale-up the innovation. In particular we are talking of a strategic design approach that should also have a key role in:

- *designing the sequence of socio-technical experiments* that can bring to gradually reinforce/improve the innovation and foster its societal embedding process;
- *identify and involve (in time) the socio-economical actors* that can support the innovations in the various steps of the transition path;
- facilitating the *building-up of a vision* (and its evolution in time) capable to converge the expectations and orient the actions of the involved stakeholders, and capable to attract new actors.

Design the sequence of socio-technical experiments

As we have seen before, niche experiments and pilot projects have a strategic importance for stimulating transition to eco-efficient PSS innovations. For this reason a potential role for strategic designers is to design the sequence of socio-technical experimentations that could bring to a gradual societal embedding of the solution. In other words the hypothesis is that strategic designers could have a role also in defining the transition paths capable to favour the implementation and diffusion of eco-efficient PSS. A path that, as underlined before, brings the innovation to be tested in protected experiments, introduced in niche market, broadened, scaled up and embedded in the regime.

The key role of design could be particular important in the first phases of this transition path, in which the experimentations are key strategic. Of course we are not speaking about experiments to be undertaken inside one company laboratory (to test only the technical aspects of the solution), but wide socio-technical experimentations. However, the key question now is: how these socio-technical experiments should be designed? Which characteristics should have? From what has been said before socio-technical experiments should be designed in order to:

- *Verify the technical and usability elements* of the innovation. The experiment should in fact bring to collect feedbacks and understand which are the adjustments and improvements to be undertaken in relation to the technical and usability aspects of the solution (changes at a product and service level). The involvement of the final users in these experiments is therefore critical.
- *Verify the acceptability by the various social groups.* Verifying the acceptability from the user point of view is not enough. In fact, if we want to favour the societal embedding of the solution it has to be understood how the different social groups (the local community, local administrations and institutions, universities and research centres, NGOs, media, etc.) respond to the innovation. Even in this case the collected feedbacks are used to adapt the innovation characteristics.
- *Favour the acceptability by the various social groups.* Socio-technical experiments should be used not only to collect feedbacks and define the adjustments to be undertaken, but also to foster change. In other words experiments should be used as agents of systemic change, stimulating what Brown and Vergragt (2008) define *higher order learning:* "changes in the assumptions, norms and interpretive frames which govern the decision-making process and actions of individuals, communities and organizations". In this sense experiments should be designed to diffuse new ideas and knowledge to the community, the local administrations, etc., and to stimulate these social groups to change their perspectives, beliefs, and lifestyles.
- *Identify implementation and diffusion barriers.* Experiments have also the role to identify the different barriers (institutional, regulative, economic, etc.) that can potentially hinder the future implementation and diffusion of the innovation.
- *Identify the policy measures to promote the innovation.* Since eco-efficient PSS innovations are promising in terms of sustainability, the socio-technical experiments should be carried out in synergy with local administrations and governmental institutions in order to understand which policy measures could be adopted to favour the innovation itself.
- *Give visibility to the project.* Pilot projects and socio-technical experiments have also the objective to show and promote the project, in order to raise the interest around the innovation, attract new stakeholders and funds. In relation to this the involvement of media and NGOs could be crucial.

Design the supporting stakeholders network

As previously underlined, the presence of a wide and dynamic network of actors, capable to support and protect the eco-efficient PSS innovation (during its incubation, experimentations, scaling-up and branching) is key important for a successful innovation. Designers could have a role in identifying and involving the most suitable socio-economical actors: *companies* (because they can provide competences and financial resources), *universities and research centres* (because they can give scientific support and could represent the promoter and facilitator of the process), *local administrations and institutions* (because they can provide facilitations or financial resources), *NGOs* (because they can support and create interests around the innovation), *media* (because they can give visibility to the project), and of course the final users (because they are fundamental in testing and experimenting the system innovation) and the local community.

It is important to remark that the stakeholders involvement is a continuous and iterative activity along the entire transition process. This means that there is the need to define not only which actors include but also when involve them (in which phase of the transition process), and at what kind of level they have to be involved (their roles and tasks).

In other words we are dealing with a stakeholders network which is not static, but dynamic, because the actors and also the related interactions/relations could change along the transition path. A network that therefore evolves in time.

Facilitate the building-up of a shared long-term vision

To give a direction to the innovation development, and to orient stakeholders' actions, the presence of a shared long term vision is fundamental. The long term vision represents what the stakeholders involved in the project want to reach; it can be assimilated to the concept of an eco-efficient PSS.

Visioning is an activity that strategic designers are used to carry out, and several tools have been develop to support a collective building and refinement of complex solutions (see for example the *Design plan toolbox*, Jegou et al., 2004). Here the difference is that visioning takes place not only in the beginning but during the whole process of experimentation and implementation. Designers should therefore be able to continuously adapt the vision in relation to the feedbacks collected (from the involved stakeholders) during the whole transition process.

Future research steps: development of method and tools to operatively support designers

It has been argued that strategic design could have a role not only in generating eco-efficient PSS concepts, but also in defining transition paths to support and facilitate the introduction and diffusion of the concept itself (in particular designing the sequence of socio-technical experiments, designing the supporting stakeholders network, and facilitating the building-up of a shared vision). At this point a proper question is: how a strategic designer could operatively do that?

On the basis of the previously hypothesized strategic design approach, the unit of research *Design and system Innovation for Sustainability* (Politecnico di Milano) is currently developing a toolkit to enable strategic designers in defining transition paths for the introduction and diffusion of eco-efficient PSS innovations. It will consists of three parts:

- a *theoretical part*, presenting the relevant basic knowledge "translated" for strategic designers;
- a *practical part*, presenting approach, method and tools for designers;
- and an *exemplificative part* describing examples of applications of the design approach, method and tools.

The toolkit will be formed by five cluster (following the innovation cycle illustrated in section 2.2):

- **Stakeholders arena establishment and development.** Guidelines and tools to: facilitate the establishment, management and development of the social network around the project; monitor in

time the actors and social groups directly and indirectly involved in the project and their reciprocal interactions and relations; identify related convergences, conflicts, interests and power.

- **Vision building and expectation shaping:** Guidelines and tools to: build up a long term vision (eco-efficient PSS concept) shared between the actors and social groups involved in the project; identify the related barriers and opportunities; identify changes (in the social, cultural, behavioural, technological, market, regulative domains) necessary for facilitating the achievement of the long term vision.
- **Transition path development.** Guidelines and tools to translate the vision into the steps needed to support and facilitate the process of incubation, experimentation, niche introduction, scaling-up and diffusion of the eco-efficient PSS concept.
- **Socio-technical experiments execution.** Guidelines and tools to design and implement socio-technical experiment/s and pilot projects in order to incubate, test, scale-up and branch the eco-efficient PSS concept.
- **Evaluation and learning.** Guidelines and tools to monitor and evaluate: the socio-technical experiments executions and the related results; and in general the current status of the transition process. This in order to identify the adjustments to be undertaken in relation to the stakeholders network, the long term vision, and the transition path.

The method and the related tools will be tested in the next months in a project commissioned by Tetra Pak (this research project is aimed at designing an eco-efficient PSS concept and define the most effective strategy to speed up its introduction and diffusion), in order to be experimentally validated and improved.

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About the author

Fabrizio Ceschin, master degree in Industrial Design at Politecnico di Milano, since 2006 works as researcher in the *Design and system Innovation for Sustainability (DIS)* research unit, inside the Design department (INDACO) of Politecnico di Milano, dealing with innovation, design and development of products, services and systems, targeting sustainable results. He is currently a PhD candidate in Design, working on the issue of 'design and radical changes for sustainability'. He took part in several research projects commissioned by companies and researches funded by EU (among which 'SCORE!, Sustainable Consumption Research Exchange!'). He is currently the Project Manager of the EU funded research 'LeNS, the Learning Network on Sustainability'.

Contact details: Politecnico di Milano, INDACO Department, Design and system Innovation for Sustainability, via Durando 38/a, 20158 Milan, Italy; tel: +39 02 2399 7203; email: fabrizio.ceschin@polimi.it