The Role of Socio-Technical Experiments in introducing Sustainable Product-Service System Innovations

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This is the pre-print version of the chapter published in 2015 by Springer in the book "The Handbook of Service Innovation" (edited by Renu Agarwal, Willem Selen, Göran Roos and Roy Green).

The final publication is available at Springer via http://dx.doi.org/10.1007/978-1-4471-6590-3_18

Abstract

Product-Service System (PSS) innovations represent a promising approach to sustainability, but their implementation and diffusion is hindered by several cultural, corporate and regulative barriers. Hence, an important challenge is not only to conceive sustainable PSS concepts, but also to understand how to manage, support and orient the introduction and diffusion of these concepts. Building upon insights from transition studies (in particular the concepts of Strategic Niche Management and Transition Management), and through an action research project, the chapter investigates the role of design in introducing sustainable radical service innovations. A key role is given to the implementation of socio-technical experiments, partially protected spaces where innovations can be incubated and tested, become more mature, and potentially favor the implementation and scaling up process.

Key words: Product-Service System; Transition Management; Strategic Niche Management; Socio-technical experiment; Strategic design

1 Introduction

1.1 Transition towards Sustainability and the Need of Radical Innovations

After decades in which natural resources were considered inexhaustible and the resilience capacity of the Earth was not an issue, we are now fully aware of the effects that our actions have produced on ecosystems since the beginning of the industrial revolution. The pressure of human beings on the environment has in fact profoundly modified natural systems, and today the planet is reaching its limits in the capacity of assimilating environmental effects caused by anthropic activities (Rockström et al. 2009).

In the last few decades the reaction of humankind to sustainability problems has produced a series of approaches that has evolved from end-of-pipe interventions to cleaner production solutions and product eco-design strategies (Simons et al. 2001). However, although these kinds of interventions are fundamental and necessary, they are not sufficient to lead to the drastic reduction of resources consumption required to achieve sustainability conditions.[1] Although it is true that the adoption of these strategies can improve the environmental performance of products and production processes, it is also true that these improvements are often negatively counterbalanced by continuous population growth and increasing consumption levels (Scmidt-Bleek 1996; Brookes 2000).

For these reasons, under discussion there are not only production processes and artifacts, but also patterns of consumption and access to goods and services (Manzini 1999). This means that if we want to effectively tackle sustainability, there is a need to move from a focus on product and production processes improvements only, towards a wider systemic approach that takes in consideration new potential ways of satisfying the social demand of wellbeing. A profound a radical redefinition of current structures of production and consumption is therefore required.

1.2 Product-Service System Innovation as a Promising Model for Sustainability

A concept that theoretically and practically represents a promising model to steer our production and consumption systems towards sustainability is the *Product-Service System (PSS)* one. PSSs can be described as specific types of value proposition that shift the business focus from selling products to offering a combination of products and services jointly capable to achieve a final user satisfaction (Goedkoop et al. 1999; Mont 2002). In other words a PSS is oriented to satisfy customers through the delivery of functions (e.g. mobility, having clean clothes, thermal comfort, etc.) rather than the selling of products (e.g. cars, washing machines and powder, boilers and methane, etc.).

PSS is not a new economic concept: several examples of PSS have in fact been implemented in the last decades by various companies (e.g. Goedkoop et al. 1999; UNEP 2002; Mont 2004). However, the key point to be underlined is that a PSS, if

[1] Several studies indicate that we can only consider sustainable those socio-technical systems whose use of environmental resources is at least 90% less than what is currently done in mature industrial contexts (Schmidt-Bleek 1996).

properly conceived, can offer an economic and competitive incentive for stakeholders involved to continuously seek improvements in resource management (White et al. 1999; Stahel 2000; Heiskanen and Jalas 2000; UNEP 2002). It is a model that changes the reward system because producers and providers are paid per unit of performance delivered and not per unit of product sold. Thus, it can potentially delink resource consumption from its traditional connection with profit.

An example might be useful to better understand the PSS concept: the Pay-per-Use solution, a PSS developed by Ariston (an Italian appliances producer). Here, rather than selling a washing machine, Ariston offers to clients the possibility to have clean cloths without owning the product. The payment is based on number of washes and includes the delivery of a washing machine at home, electricity supply (not directly paid by the customer), maintenance, and end-of-life collection. Why is this PSS concept promising in terms of sustainability? Because within this business model Ariston is economically incentivized in reducing as much as possible the washing machine energy consumption (in order to reduce operational costs and maximize profits), and in designing and providing long lasting, reusable and recyclable washing machines (in order to postpone the disposal costs and reducing the costs for the manufacturing of new washing machines).

In sum, Product-Service System innovations represent a promising approach to sustainability, potentially capable (if properly conceived) to provide a wide range of benefits. For companies, it means the possibility to find new strategic market opportunities (Goedkoop et al. 1999; Manzini et al. 2001; Mont 2002), increase their competitiveness, and establish a longer and stronger relationship with customers (Manzini et al. 2001; UNEP 2002; Mont 2004). For customers/users, it means an increased value through a more personalized offer (Mont 2002; Cook et al. 2006) and the release from the responsibilities of ownership (Mont 2002). For the environment it means the decoupling of value creation from material and energy consumption.

1.3 Research Challenge

In the last decade a wide number of research projects in the field of PSS and sustainability have been supported by EU funding.[2] This led the research community to deeply investigate this kind of innovation, collecting and analyzing an extensive number of cases in diverse sectors, and increasing the understanding of the potential benefits, drivers and barriers. Also, several methods and tools have been developed in the last years to orient and support the designing of eco-efficient PSSs.[3]

However, despite all the knowledge accumulated, it has to be underlined that the uptake of this business concept by companies is still very limited. The reason is that sustainable PSSs can be considered, in most of the cases, *radical innovations*, because they challenge existing customer habits (cultural barriers), organizational structures (corporate barriers) and regulative frameworks (regulative barriers). In other words,

[2] For instance: *PROSECCO, Product & Service Co-Design process* (2002-2004, FP5); *HiCS, Highly Costumerized Solutions* (2001-2004, FP5); *MEPSS, Method for PSS development* (2001-2004, FP5); *SusProNet, the sustainable product service design network* (2002-2004, FP5); *SCORE!, Sustainable COncumption Research Exchange!* (2006-2009, FP6).

[3] For an extensive review of PSS design methods and tools see Tukker and Tischner (2006a).

their introduction and scaling up require breaking down the routine behaviour that is daily produced by individuals, groups, business communities, policy actors and society at large.

For this reason the introduction and scaling-up of such innovations are not completely under the control of a single actor (or a small network of actors), because changes in the factors that form the boundary conditions (i.e. existing organizations, institutions, networks, dominant practices, interests etc.), are as well required. Therefore the challenge is not only to conceive sustainable PSS concepts (several methods and tools can in fact be used to support this task), but also to understand which strategies and development pathways are the most appropriate to favour and hasten their introduction and scaling up. There is in fact *a knowledge gap regarding the dynamics, mechanism and factors driving the implementation and diffusion of this kind of innovations* and, consequently, there is a lack of strategies, approaches and tools to enable *strategic designers, project managers* and *management consultants* in designing, managing and orienting this process. This study focuses on this unexplored research area.

Recent advancements in the *transition studies* field have provided insights into how to understand, influence and orient the adoption of radical innovations. According to these theories, the introduction of radical innovations requires the creation of partially protected *socio-technical experiments* (Kemp et al. 1998, Hoogma et al. 2002; Brown et al. 2003; Van den Bosch 2010). Protection allows incubation and maturation of radical socio-technical configurations by partly shielding them from the mainstream market selection environment.

This chapter proposes the adoption and adaptation of concepts and insights from transition studies into Product-Service System design and innovation. In particular the chapter seeks to explore the potential contribution that socio-technical experiments can make in stimulating, supporting and hastening the process of introduction and scaling-up of sustainable PSS innovations. A particular emphasis is on the design approaches and capabilities required to develop and manage this kind of socio-technical experiments.

1.4 Chapter Organization

The chapter begins by illustrating the barriers which hinder the implementation and diffusion of sustainable PSS innovations. Then it presents how concepts and theories from transition studies (in particular the concept of socio-technical experiment) could provide a framework to understand and orient radical innovations. After illustrating the research questions and approach, the chapter continues by presenting an action research project, called *Cape Town sustainable mobility*, aimed at designing and implementing a radical innovation: a sustainable mobility PSS for the disabled and elderly people in the suburban areas of Cape Town. Building upon the project experience, the chapter discusses the implications for design and management. In this respect the chapter provides a first framework of action by suggesting the adoption of key approaches and principles.

2 The Challenge of Implementing Sustainable Product-Service System Innovations

Despite all the knowledge accumulated on understanding how to develop sustainable PSSs, and despite their potential win-win characteristics, the diffusion of this concept is still very limited. The reason is that sustainable PSSs are intrinsically radical innovations, and the adoption of such business strategies brings with significant corporate, cultural and regulatory challenges.

For *companies* the adoption of a sustainable PSS strategy is more complex to be managed than the traditional way of delivering products alone. In fact there is the need to implement changes in corporate culture and organization in order to support a more systemic innovation and service-oriented business (UNEP 2002), and the need to cope with an internal resistance to extend the involvement with a product beyond point-of-sale (Stoughton et al. 1998). Moreover, since PSSs determine the changing of systems and sources of gaining profit, this could deter producers from employing this concept (Mont 2002): PSSs in fact require medium-long term investments and are connected with uncertainties about cash flows (Mont 2004). 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). In synthesis companies require, as a consequence, new design and management knowledge and skills.

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; Mont 2002; UNEP 2002). In fact, as argued by Behrendt et al. (2003), the problem is that solutions based on sharing and access contradict the dominant and well established norm of ownership, and requires new customer habits and behaviors. It has also to be underlined that product ownership not only provides function to private users, but also status, image and a sense of control (James and Hopkinson 2002); elements which are sometimes missing in ownerless based solutions. Another obstacle is the lack of knowledge about life cycle costs (White et al. 1999), which makes it difficult for a user to understand the economic advantages of ownerless based solutions.

On the *regulatory* side, environmental innovation is often not rewarded at the company level due to lack of internalization of environmental impacts (Mont and Lindhqvist 2003). In addition governments face difficulties in implementing appropriate policies to create corporate drivers to facilitate the promotion and diffusion of this kind of innovations (Mont and Lindhqvist 2003; Ceschin and Vezzoli 2010).

In sum, sustainable PSS innovations usually encounter the opposition of the existing socio-technical context because in most of the cases they require a profound redefinition of the production and consumption modalities. Therefore they may cope with the current and dominant socio-technical systems (and their established and relatively stable set of rules and networks of actors) (Tukker and Tischner 2006b; Ceschin 2013a). In other words they can be usually considered radical innovations, and as such they may involve fundamental changes in *culture* (the sum of norms and

values that together constitute the perspective from which actors think and act), *practice* (the sum of routines and behaviors), *institutional structures* (rules, regulations, power structures), and *economic structures* (market, financing, consumption, production) (Rotmans and Loorbach 2010).

As a result sustainable PSS innovations are often immature when they enter the market and therefore have high probability not to survive under the mainstream selection environment. Since the diffusion of sustainable PSSs requires changes in contextual factors conditions, a much broader system approach is therefore needed to facilitate the societal embedding of this kind of innovations.

3 Insights from Transition Studies

The challenge of understanding radical innovations has been addressed by innovation studies. Recent developments in this field (in particular the Strategic Niche Management and Transition Management approaches) have focused on socio-technical transitions and have brought insights on how to facilitate the introduction and diffusion of radical innovations.

3.1 Dynamics in Socio-Technical Transitions

Transition theorists refer to system or radical 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, economic, technological and policy domains. Through historical socio-technical case studies, transition scholars have analyzed how system innovations take place and have elaborated a model called the multi-level perspective on transitions (Geels 2002) that describes the dynamics regulating these complex and long-term processes. The multi-level perspective distinguishes three analytical concepts (ibid.):

- the *socio-technical regime*, which can be defined as the dominant way of innovating, producing, distributing, consuming etc. It refers to a dynamically stable set of culture, practices and institutions (Rotmans et al. 2001) related to a specific field (e.g. mobility or energy). Regimes are relatively stable and resistant to change because their practices, 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 and nurtured, become more mature, and potentially challenge and change regime practices and institutions; 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 includes structural socio-economic, demographic, political and international developments, but also events such as wars or environmental disasters. It can influence the regime and the niches but cannot be influenced by them (at least in the short term).

Transitions take place through the fruitful coupling of developments at all three levels (Rip and Kemp 1998; Geels 2002): when the regime is sufficiently open to accept radical innovations; when there is enough pressure from the landscape; and when radical innovations developed in niches can exploit the opportunities for change.

Niches are therefore a crucial step towards a regime shift because they can shield radical innovations from market competition and allow continuous experimentation to lead innovations to mature (Schot and Hoogma 1996). In other words niches can act as *'incubation rooms'* for radical novelties (Geels 2002), where socio-technical experimentation and learning processes take place. Thus, it clearly emerges that an important pre-requisite to the introduction of radical innovations is the creation of partially protected environments where to conduct *socio-technical experiments*.

3.2 The Role of Socio-Technical Experiments in Triggering Radical Innovations

Several concepts referring to socio-technical experimentation have been elaborated in the last years.[4] Even if each concept presents its own peculiarities, a socio-technical experiment can be described as a partially protected environment where a broad network of actors can learn and explore (I) how to incubate and improve radical innovations and (II) how to contribute to their societal embedding. Its main characteristics are as follows.

Firstly, *experiments are conducted with radical innovations*: innovations that require substantial changes on various dimensions (socio-cultural, technological, regulative and institutional).

Secondly, experiments are not simple tests undertaken inside a company's laboratory but are implemented in *real life settings*. The idea is that only this kind of experience, outside the R&D settings, can truly lead to testing and improving radical innovations. Moreover these experiments take place at a small scale but strive to trigger changes at a wider scale.

Thirdly, these experiments do not include only the actors more strictly linked to the innovation (such as producers, partners and suppliers). Instead, *a broad variety of actors is involved*, including also users, policy-makers, local administrations, NGOs, consumer groups, industrial associations, research centres, etc. In other words the aim is to recreate a whole socio-technical environment in a small scale. In this sense these experiments are characterized by a broad participatory approach (i.e. a variety of actors is involved in discussing, negotiating, co-creating and developing the innovation).

Fourthly, the experiment is implemented in a *space protected from the mainstream selection environment*. The idea is to temporarily shield the innovation from the selection pressure (which consists of markets and institutional factors), creating an alternative selection environment. There are different forms of protection: financial protection (such as strategic investments by companies, tax exemptions, and

[4] The most diffused ones are: *social experiments* (Verheul and Vergragt 1995), *experiments in Strategic Niche Management* (Kemp et al. 1998), *transition experiments* (Rotmans et al. 2000; Van den Bosch 2010), *bounded socio-technical experiments* (Brown et al. 2003).

investment grants) and socio-institutional protection (such as the adoption of specific regulations).[5]

The aim of these experiments is to *learn about and improve the innovation on multiple dimensions*, not only the technical, economic, market demand and usability aspects, but also the political, regulative, environmental, cultural and social dimensions. In this sense the innovation is maintained open to continuous adjustments and refinements. In general experiments can also serve to identify the various resistances and barriers (institutional, regulative, economic, etc.) that can potentially hinder the future implementation and diffusion and understand how to address them.

Moreover, and this is a crucial aspect, socio-technical experiments are not only aimed at testing and improving the innovation, but also at *stimulating changes in the socio-technical context*, in order to create the most favorable conditions for the innovation. In other words experiments are also strategically used to influence contextual conditions in order to favor and hasten the societal embedding process (for example, by influencing local administrations to adopt policy measures that support the innovation, or stimulating potential users to change their behaviors and routines).

In sum, socio-technical experiments can enhance the process of transitioning to sustainable radical innovations because they can simultaneously act as (Ceschin 2012; Ceschin 2013c):

- *Labs*, to test, learn about and improve the innovation on multiple dimensions (technical, usability, regulative, political, economic, and socio-cultural). This entails a *"deepening"* process (Van den Bosch 2010), which means learning as much as possible about an innovation within a specific context, enabling actors to learn about local shifts in culture (ways of thinking, values, reference frameworks, etc.), practices (habits, ways of doing things, etc.) and institutions (norms, rules, etc.). The result is a continuous development and reinforcement of the new set of culture, practices and institutions related to the new innovation.
- *Windows*, to raise interest in the innovation project and the related actors, disseminate results, build up synergies with existing similar projects/initiatives, and attract and enroll new actors (e.g. new users or potential partners). In other words experiments can be used as communication and conversation tools to stimulate and facilitate interaction with new social actors.
- *Agents of Change*, to influence contextual conditions in order to promote and quicken the transitioning process. Experiments should be conceived to create and diffuse new ideas and knowledge, and stimulate various social groups (users, public institutions, companies, etc.) to change their perspectives, beliefs, and behavior. Learning processes are seen as drivers for radical changes, and socio-technical experiments should represent a stimulus to induce these processes, and lead actors to reframe their behaviors and attitudes (for example, they can stimulate users to rethink and change their behaviors and routines).

[5] The crucial dilemma of protection measures is to find the right balance between the need to nurture the innovation and the need to prepare it for the selection pressures of a market environment (Weber et al. 1999).

It has however to be stressed out that single experiments do not result in regime changes. Sequences of articulated local experiments are needed to gradually reinforce themselves andlead to wider changes (Raven 2005; Geels and Raven 2006). This is the process that Van den Bosch (2010) calls *"broadening",* which means replicating the experiment in different contexts and linking it to other projects and initiatives. Since learning within an experiment is limited, experiments should be repeated in other contexts, in order to learn about different designs in different settings. It is also important to strength synergies with other local similar projects and initiatives. In this respect Meroni (2008) and Jegou (2011) speak about *"synergizing"* or *"acupunctural planning",* a set of synergic self-standing local initiatives that, adopting as a metaphor the practice of the traditional Chinese medicine, aim to generate changes in large and complex systems operating on some of their sensible nodes.

From what it has been said above, it appears promising to create a bridge between the disciplines of PSS design and transition studies. The hypothesis is that the adoption and adaptation of principles and concepts from transition studies can enrich and advance the current debate on the role of design in PSS innovation.

4 Research Questions and Approach

If transition studies can provide insights on how radical innovations can be initiated and supported, the questions at this point are: how lessons from transition studies can be integrated into PSS design and innovation? What role can PSS designers play in initiating, supporting and developing socio-technical experiments? What design approach and capabilities do they require?

When aiming at addressing this kind of research questions, the main challenge is related to the timeframe of sustainable radical innovations. In fact the process of introduction and scaling-up of sustainable PSSs and sustainable social innovations might require several years. Therefore the implementation and testing of design approaches/strategies cannot be studied in a real time perspective. In order to tackle this challenge, the adopted methodology was based on the combination of three different research approaches[6] (Figure 1).

- The first step was a *case study research aimed at verifying if principles and concepts from transition studies were also valid for PSS innovations* (the case study is not described in this paper but in Ceschin (2013a) and Ceschin (2012)). The process of implementation and scaling-up of six sustainable PSSs was analyzed.[7] The case study research showed that the setting-up of sequences of socio-technical experiments (capable to act as *Labs*, *Windows* and *Agents of change*) represents a crucial step to support and hasten the incubation, testing and maturation of sustainable PSS innovations, and potentially their scaling up.
- Building upon the results of the case study research, the second step focused on exploring the implications for design. An *action research project*, aimed at

[6] For a detailed description of the research methodology see Ceschin (2012).

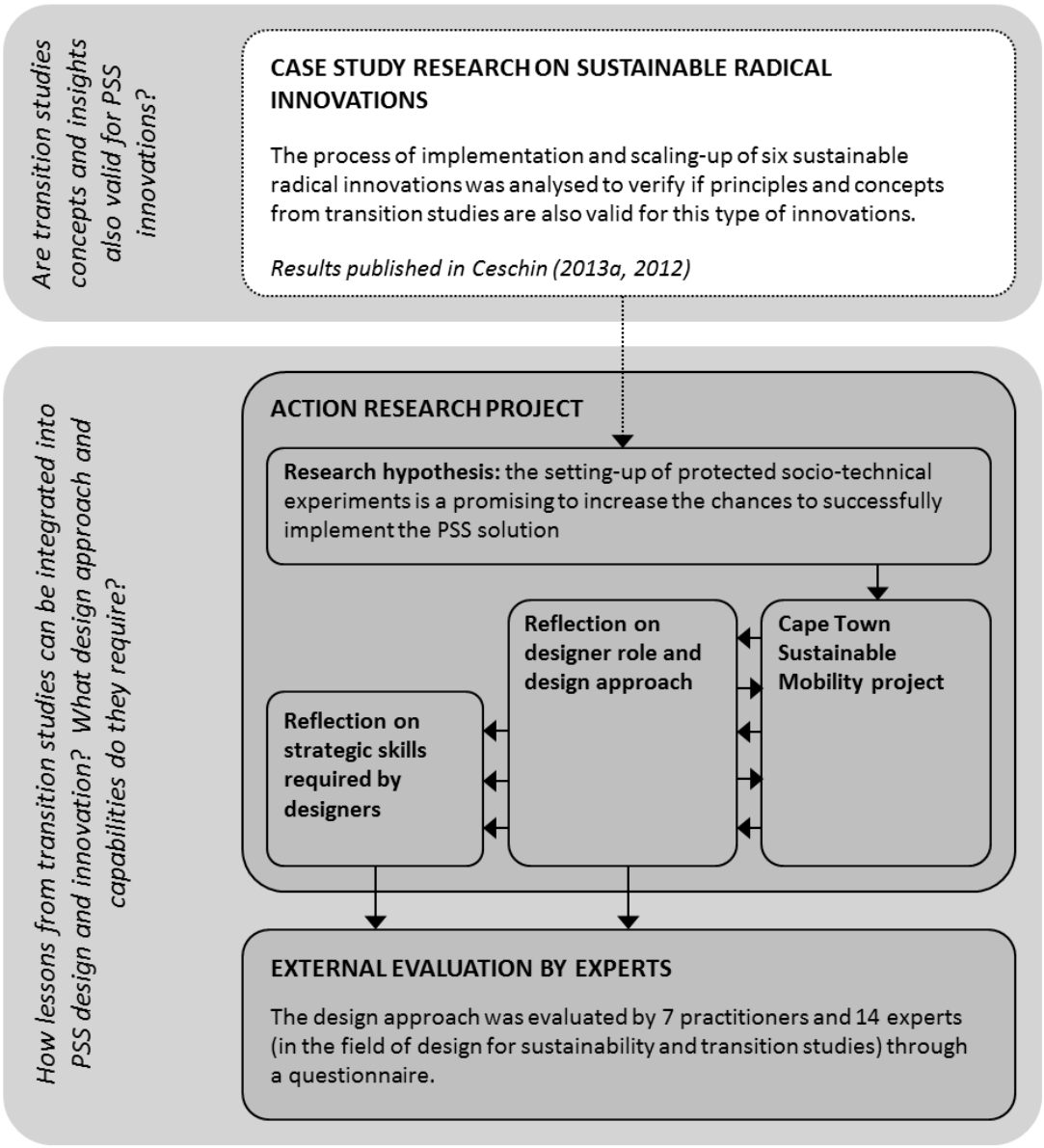
[7] In particular the analysis focused on: the role of socio-technical experiments; the socio-economic actors involved during the process; the negotiation processes and alignment of actors' expectations; the actors learning processes.

designing, introducing and diffusing a sustainable mobility system in the suburban areas of Cape Town, was undertaken. The project was used to reflect on the design approach adopted, and constantly develop insights on how to refine and make it more effectively applicable to practice. This was an iterative process in which researchers were continuously involved in applying the design approach and reflecting on how to improve it. In fact action research seeks to *"bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people"* (Reason and Bradbury 2001), in an iterative cycle of planning, acting, observing and reflecting (Kemmis and McTaggart 1988).The author was part of a research team directly involved in the project management, participating in the design activities as well as interacting with the other actors and practitioners involved in the project.

- The third step was an external assessment made by academic experts and practitioners in the field of PSS innovation and transition studies. The results of the action research project were used to elaborate a design approach. This design approach was evaluated by 7 practitioners and 14 academic experts through a questionnaire. In particular participants were asked to evaluate the design approach in relation to its potential practicality (how much the approach is usable in the settings for which it has been conceived), and effectiveness (how much the use of the approach might led to desired outcomes). Both open-ended and closed-ended questions were included in the questionnaire. 6 out of 7 practitioners affirmed that they could use the approach (partly or entirely) as guidelines for on-the-job application. Regarding academic experts, 13 out of 14 stated that the approach and the action research project are useful as reference material (in particular as a teaching resource), and 9 out of 14 affirmed that they could use it as guidelines for on-the-job application (in particular in applied research projects).

In sum, the process to answer to the research questions was not linear but rather *iterative* and *interactive*. *Iterative*, because the design approach was implemented in a practical design experience and continuously developed, adjusted and refined during the whole design process. *Interactive*, because the process was characterized by a continuous collaboration among researchers, practitioners and experts (who continuously brought input on how to improve the design approach). Even if the research had a non-linear (iterative) character, the choice is to not present the activities undertaken in a completely chronological way. Rather, for the sake of clarity, the choice is to firstly present the action research project and then the reflection on the design role and approach.

Figure 1 *Research questions and approach.*



5 Implications for PSS design and management

5.1 Cape Town Sustainable Mobility Project

5.1.1 Project Background

The Cape Town Sustainable Mobility project currently involves, as main actors, *Shonaquip* (a small South African company producing wheelchairs and mobility equipment for disabled people), *Bicycle Empowerment Network* (BEN Bikes, a local association aimed at promoting sustainable mobility projects and initiatives), the *Cape Peninsula University of Technology* (CPUT), and *Politecnico di Milano* (Polimi).

The aim of the project is to introduce and diffuse a sustainable mobility Product-Service System (PSS) for the disabled and elderly people in the suburban areas of Cape Town. In particular the system is expected to offer disabled and elderly people

increased mobility services from their homes to the nearest public transport stops, or to local schools, hospitals, etc. Technically, the mobility system is designed around a solar, electric and human powered light vehicle.[8] This mobility system is especially conceived to create benefits in suburbs such as those in Cape Town, which are often characterized by substantial mobility problems due to a lack of high quality public transport services. The initial PSS concept was developed by Hazal Gumus for her master's degree thesis,[9] conducted in collaboration with Polimi and CPUT. The thesis project raised the interest of Shonaquip and in July 2009, a process to socially embed the PSS innovation officially started.

The initial assumption which drove the implementation strategy was that the setting-up of protected socio-technical experiments (with the characteristics described in section 4.2.3.2) would have been promising to increase the chances to successfully implement the PSS solution.

The activities undertaken in the project can be grouped in three main phases:

- *incubation*, aimed at setting up the conditions needed to start the societal embedding process;
- *socio-technical experimentation*, aimed at implementing the first socio-technical experiments, to learn and explore how to improve the PSS innovation and how to favor and support its societal embedding;
- and *scaling-up*, aimed at removing protection and transforming the experiments in a fully operative service.

At the time of the writing of this chapter the project consortium is in the between of the second and the third phases.

5.1.2 Incubation

The project started with the first formalization of the project vision. The aim was to translate the initial project idea into a set of visual artifacts to clearly and effectively communicate the PSS innovation characteristics and its potential benefits to different types of actors. A set of visualization tools was used to support this task.[10]

Starting from the PSS vision, the next step was the development of a draft transition path (action plan), to identify the main steps between the present situation and a future situation with the PSS implemented. Actors involved in these first two steps were the research team (made up of academics and research students from *Polimi* and *CPUT*) and *Shonaquip*.

The following step was the identification of actors to be involved in strategic discussions. It was decided to firstly include a restricted group of actors (the ones

[8] Prototyped by IPSIA "A. Ferrari" Maranello and Politecnico di Milano in 2006.

[9] Gumus, H. (2009) Kanga: a sustainable system design for the transportation of learners with disabilities in Cape Town – South Africa. Master's degree thesis. Politecnico di Milano.

[10] Among them: (I) the *offering diagram*, to succinctly visualize what the PSS offers to customers; (II) the *interaction table*, to visualize how the PSS offer is delivered to customers (sequence of interactions occurring at front-desk level and back-stage level); (III) the *system map*, to visualize the structure of the value chain; (IV) the *sustainability diagram*, to visualize the environmental, socio-ethical and economic benefits delivered by the PSS.

considered crucial to start discussing and strengthening the PSS concept and the transition path) and later extend participation to a wider variety of actors such as the Cape Town municipality, the local public transport company, and local media. Actors initially involved were potential users, local citizens, technology experts from CPUT, and two local NGOs: *Disability Workshop Enterprise Development, DWDE* (active in providing job opportunities to disabled people) and *the Reconstructed Team* (an association aimed at reintegrating into society former drug addicts and criminals).

A two-day workshop was organized in September 2009. The workshop began with the illustration of the project vision and the draft action plan; project promoters used the visual artifacts elaborated in the previous steps as a basis for the presentation. The first day focused on discussing and adjusting the project vision. In order to stimulate discussion, participants were asked to analyze the vision in relation to different socio-technical dimensions (technological, political, cultural, etc.) and identify conflicting issues. Participants were then asked to think about potential alternatives to solve the conflicting issues that had emerged. The collective discussion about the PSS concept and the context opportunities and barriers resulted in adjusting and refining the project vision at the end of the first day. The second day of the workshop focused on discussing the transition path, identifying: (I) steps and actions to be undertaken; (II) actors to be involved in the different steps; and (III) roles and tasks to be assigned to each actor. In sum the workshop led to:

- *Adjust the PSS concept.* It was decided to also offer a transportation service for tourists within the city centre (in order to increase the sources of revenue). In relation to the vehicle, the design requirements were specified.
- *Adjust the transition path.* In particular it was agreed that the next step would have been the implementation of a small-scale experiment in the Athlone district (focused only on the transportation of elderly people), to be later extended to other suburban areas of Cape Town.
- *Identify implementation barriers.* The main problem that emerged was the unavailability of financial resources to entirely finance the vehicles' production and the pilot implementation. Moreover another concern was related to the local availability of solar panels and lithium batteries. Finally it emerged that local regulations did not allow the use of human-powered vehicles for public mobility services.
- *Identify new actors to be involved.* It was recommended to establish connections with Cape Town municipality (and in particular the transport department) to solve the previously mentioned regulative issues and develop synergies with the public transport service. Moreover it was suggested to identify and involve an actor that could manage the tourist transportation service in the city centre.
- *Agree on the tasks to be assigned to each actor.* In particular it was agreed that Shonaquip would have managed the production of the vehicles (in collaboration with DWDE) and managed the service (in collaboration with the Reconstructed Team). CPUT would have redesigned the vehicle and contacted the actors to be involved. Polimi would have collaborated in the vehicle redesign and in seeking financial resources for the pilot project.

In sum, the result of this phase was the building up of a first network of actors and the development of a shared project vision and a first hypothesis of transition strategy.

The involvement in this first phase of a broad variety of actors was crucial in order to allow the project consortium to focus on different dimensions of the problem (technical, economic, sustainability, usability, etc.). On the other hand, it emerged the difficulty to coordinate and manage discussions among a variety of actors, and the need of a network manager capable to act to manage controversies and conflicts within the network and establish bridges between different actors' expectations.

5.1.3 Socio-technical experimentation

In the second phase two socio-technical experiments were designed and implemented. The first experiment was implemented in the Athlone district (Bridgetown), in collaboration with the *Reconstructed Team*, and was aimed only at testing and improving the technical and usability aspects of the PSS innovation. In the first stage, before concluding the vehicle construction, an existing rickshaw was used to test the service of transporting the elderly in the neighborhood, involving them in identifying critical issues and suggesting potential improvements (Figures 2 and 3). In the second stage, once the vehicle prototype was completed, a series of technical tests took place (Figure 4 and 5). After having settled the vehicle's technical problems and collected the first feedback on the service, the project consortium was ready to start the experimentation with users and the new vehicle. However, at this stage the *Reconstructed Team* decided to leave the consortium. It was an unexpected decision, even because of the positive response given by users during the service test. They explained the decision saying that due to other activities there were no personnel available to manage the complexity of this experimentation. On the other hand they confirmed the interest to implement in future, after the experimentation phase, a full operational service with a fleet of vehicle.

Figures 2, 3: *First socio-technical experiment: photos taken during the service test (July 2011). (Reproduced from Ceschin 2012)*

Figures 4, 5*: First socio-technical experiment: photo taken during technical test of the vehicle (August 2011). (Reproduced from Ceschin 2012)*

At this stage the project consortium needed to find another actor willing to continue the experimentation and manage the implementation of a fully operative service. A contact was established with *BEN Bikes (Bicycle Empowerment Network)*. BEN Bikes is a local association aimed at addressing promoting sustainable mobility projects and initiatives and providing job opportunities for low-income people. For this purpose they have several centres located in the suburban areas of Cape Town. The defection of the Reconstructed Team and the involvement of BEN Bikes led to the adjustment of the project vision. In particular BEN Bikes proposed to use their suburban hubs as operative centres to manage local mobility services and vehicle maintenance. For this reason the second socio-technical experiment was undertaken in collaboration with one of these hubs, and in particular the one placed in the Lavender Hill suburban area. This second experiment was implemented in October 2011 and is still running. It was designed and organized in order to act as a *Lab, Window* and *Agent of Change*.

The first aim of the experiment was to test and improve the PSS innovation (***experiment as Lab***). A service for the transportation of elderly, sick and disabled people from their home to any point of interest around the Lavender Hill community (such as to the hospital, church or the post office) was implemented and is currently running (Figure 6). The main role of the local BEN Bikes centre is to manage the service as well as take care of vehicle maintenance. The experiment is currently used to:

- *Test and improve the vehicle:* the role of BEN Bikes is to check the vehicle on a daily basis, in order to report the technical problems and identify potential solutions (in collaboration with Shonaquip, CPUT and Polimi);
- *Test and improve the service:* the quality of the service is assessed using questionnaires and semi-structured interviews. Test users are asked to evaluate the service, identify critical aspects, but also to propose potential alternatives and improvements;
- *Test and improve the PSS configuration:* verify the PSS configuration in terms of stakeholder value chain and business model and identify potential improvements to be implemented. Meetings involving project promoters are scheduled on a monthly basis to discuss these issues;
- *Identify barriers:* the pilot is also used to identify potential implementation and diffusion barriers on multiple dimensions (e.g. socio-cultural and regulative). For this reason various actors (such as the local community, local institutions and NGOs) are involved to express their opinions, remarks and suggestions (regarding this see also experiment as a Window and Agent of Change). Of course most of the barriers were identified in the previous steps (during the incubation and the first experiment). However project promoters considered it crucial to use the experiment to identify any further potential barriers.

Figure 4.2.6: *Second socio-technical experiment: testing the PSS (October 2011). (Reproduced from Ceschin 2012)*

The experiment was also designed to raise interest in the innovation project and attract and enroll new potential users and other relevant actors (***experiment as Window***). It represented a working prototype of how things could work, a conversation tool aimed at enhancing participation and enabling discussions with a larger audience of relevant socio-economic actors. With respect to this the BEN Bikes centre has been conceived as a sort of 'open gallery' to allow visitors to see, touch and acquire information about the project (Figure 4.2.7). Interested people can freely visit the centre and better understand the features of the project and its environmental, socio-ethical and economic benefits. Moreover demonstration visits are organized with specific actors (for example potential users but also potential future partners, local institutions, etc.). BEN Bikes personnel have been trained to be able to effectively describe the project and in particular to illustrate the potential advantages for different kinds of actors. This was considered particularly important by project promoters because there was the need not only to disseminate information about the project but also to stimulate changes in actors' behavior and routines (for example stimulate potential users to reflect on their mobility habits and consider the benefits that the solution could provide to them). This is strictly connected to the third function of the experiment: experiment as Agent of Change.

Figure 4.2.7: *Second socio-technical experiment: interested people visiting the Lavender Hill BEN Bikes centre (October 2011). (Reproduced from Ceschin 2012)*

The experiment was also conceived to stimulate changes in actors' behavior and habits and create favorable conditions for the introduction and diffusion of the PSS (***experiment as Agent of Change***). Therefore, in October 2011 an event for relevant actors was organized. The aim of this event was to officially launch the experiment, illustrate the potential future developments, and discuss with invited actors how to support and create the conditions to accelerate the project. The event took place at the Lavender Hill BEN Bikes centre.

The actors invited to the event were:

- the *Cape Town municipality* (in particular the Transport department and the Environmental Resource Management department), because of their potential interest in the project and their direct influence on local transport regulation;
- *local actors* potentially interested in implementing specific mobility services based on the MULO vehicle: in particular local schools and the local clinic (Philiza Abafazi Bethu);
- and *local media*.

The event was structured in four parts:

- a first part aimed at illustrating the project (economic, environmental and socio-ethical benefits) and presenting the socio-technical experiment;
- a second part aimed at illustrating the project future opportunities;
- a vehicle ride demonstration;
- and a workshop with participants to discuss the potential synergies that could be built to sustain and expedite the project.

The results of the event were positive. Firstly, local actors evaluated the project as valuable for local communities, because of its potential to bring tangible economic, environmental and socio-ethical benefits. Secondly, one of the actors involved, the local clinic, stated their interest in implementing a service for the transportation of patients as soon as possible. Thirdly, the Transport department of Cape Town confirmed its interest in strengthening synergies between the PSS and the suburban

bus lines. In addition the Transport department stated they would have planned meetings in their agenda to discuss the policy measures needed to support and foster the particular vehicle typology adopted in the PSS.

5.1.4 Main intermediate project results and next steps

Starting from an initial PSS concept proposed by a small network of actors, the first project result is the building up of a broad network of actors and the alignment of their expectations towards the achievement of a shared vision. Currently, the main actors committed to the project are a company (Shonaquip), a NGO (BEN Bikes), a local institution (the Cape Town municipality), and two universities (Polimi and CPUT).

The second project result is the implementation of two socio-technical experiments in suburban areas of Cape Town. The first, in the Athlone district, tested a service for the transportation of elderly people and the technical aspects of the vehicle. The second, at Lavender Hill, is much more articulated and is still running. It is currently aimed at: testing and improving the whole PSS, raising interest in the project and enrolling new relevant actors, stimulating actors (such as potential users) to change their behavior and routines, and stimulating changes in the socio-technical context (such as changes in the regulative framework).

Because the second socio-technical experiment is still on-going, it is currently not possible to develop definitive conclusions. Nevertheless, it is possible to say that the whole journey strengthened the stakeholder network, served to refine and improve the PSS concept, and created important opportunities for future developments. In this regard it can be mentioned that:

- local actors located at Lavender Hill (the clinic and the school) stated their interest in implementing mobility services specifically dedicated to their needs;
- the 14 BEN Bikes centres, located in the Cape Town suburbs, could represent crucial hubs to replicate the experiment in other areas of the city;
- BEN Bikes is also interested in implementing a service for tourist transportation in the city centre;
- the Cape Town municipality is interested in creating synergies with the PSS and the public transport services (in particular in relation to the suburban bus lines).

5.2 A New Design and Management Approach: Designing Transition Paths and Socio-Technical Experiments

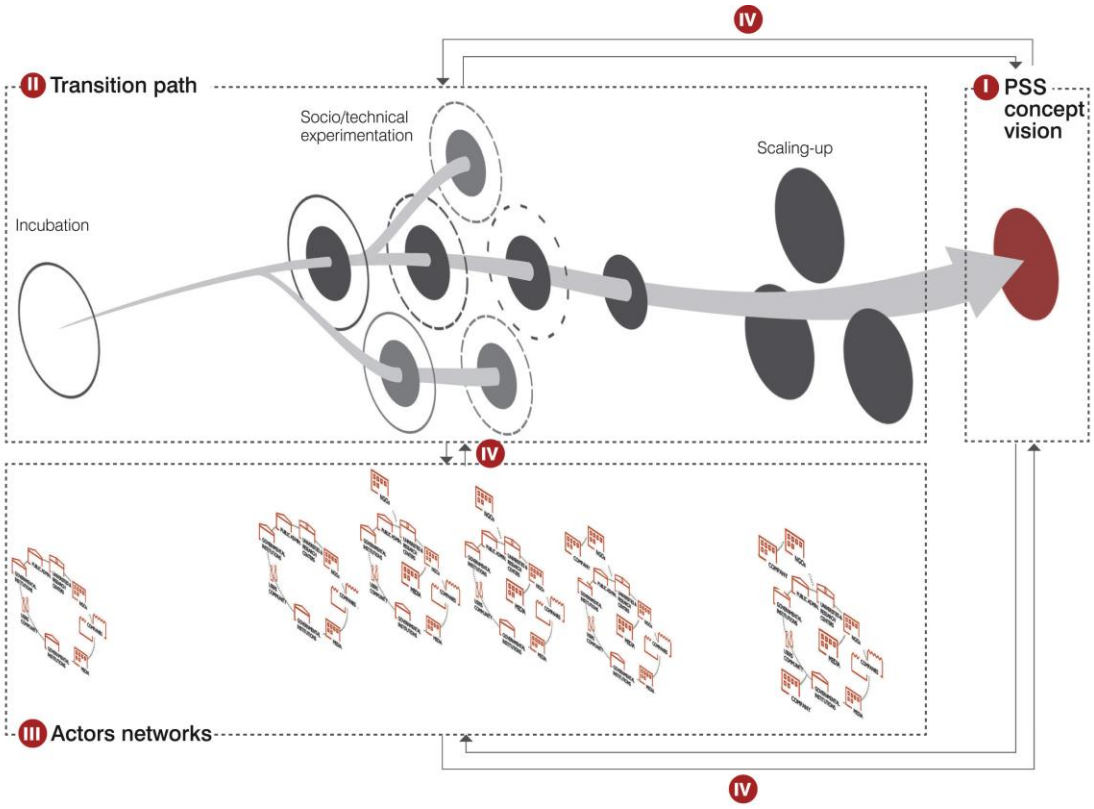
In the Cape Town Sustainable Mobility project, the first important consideration to be done is that *design* had a role not only in conceiving and developing the PSS innovation but also in supporting and catalyzing the process of transitioning towards the implementation and scaling-up of the innovation. We can say that the approach adopted in the project was characterized by a **broad design scope**. In fact, in addition

to the ideation and development of the PSS concept (the long term project vision), the focus has been in the *designing of a transition path* (Figure 8).

In particular the design scope focused on: (i) the *design of the sequence of steps* to gradually reinforce/improve the innovation and foster its societal embedding (incubation, socio-technical experimentation and scaling-up), and (ii) the *identification and involvement of the actors* that can support the societal embedding process in the various steps of the transition path.

In other words design focused not only on generating a vision of how a mobility need could be met in an alternative and more sustainable way, but also on how to achieve that vision. And in this transition path a crucial role is played by socio-technical experiments, conceived not only as *labs* and *windows*, but also as *agents of change*.

Figure 8: *A broader design scope. Design has a role not only in ideating and developing sustainable innovation concepts (1), but also in triggering and orienting transitioning processes through the designing of the sequence of phases and steps (2), and identification of the actors to be involved along the whole process (3). (Reproduced from Ceschin 2012)*

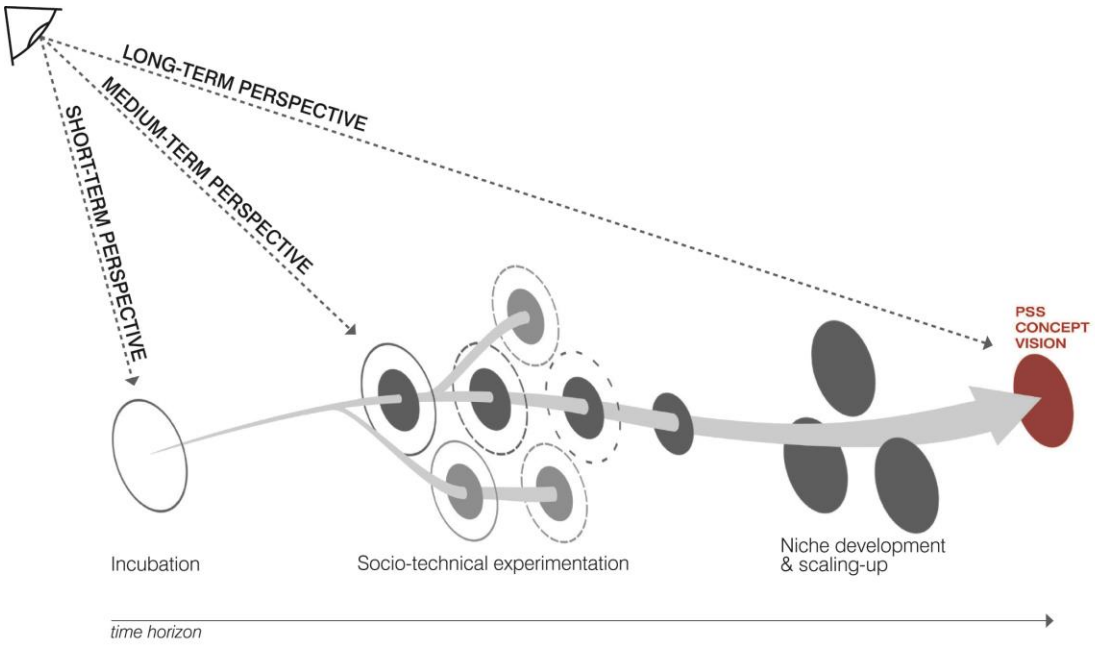


The first consequence of this design approach is that design should simultaneously focus on different time frames. The Cape Town Sustainable Mobility experience showed that project actors adopted a *multi-term design attitude* (Figure 9), because they simultaneously focused on:

- the *project long-term goal (project vision):* the achievement of a future in which a the Cape Town Sustainable Mobility system is part of the usual way in which a particular mobility need is fulfilled; and
- the *short- and medium-term actions* to be undertaken in order to orient the innovation journey towards the achievement of the project vision: the incubation of the innovation and the implementation of two socio-technical experiments.

The project vision and the strategy to achieve the vision are not designed separately. Traditionally, the design of a solution is seen as a separate activity from the realization of that solution. Here, there is not this dichotomy: the design of the project vision requires to be done simultaneously with the design of the transition path.

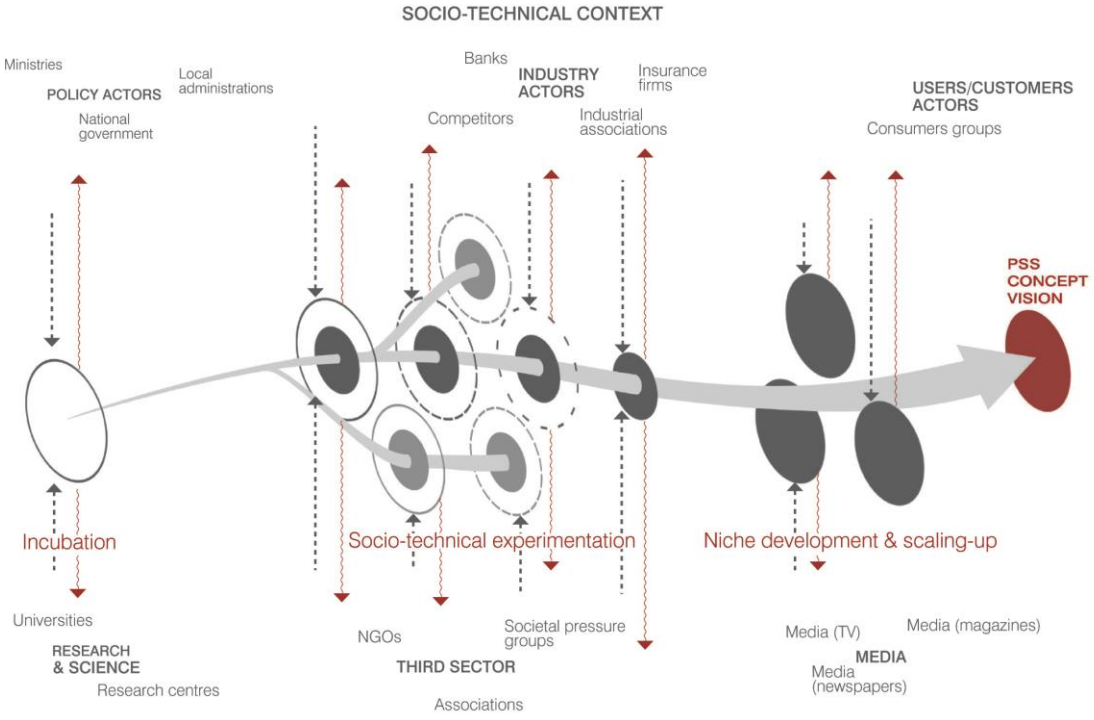
Figure 9: *The multi-term design attitude. The focus is simultaneously on different time frames. (Reproduced from Ceschin 2012)*



We can also observe that a **strategic design approach** has been adopted by project promoters (Figure 10). In fact the project actors focused not only on the solution (the PSS innovation) but also on the technical, socio-cultural, institutional and organizational contextual conditions that might have favored or hindered the societal embedding process. The project consortium tried to trigger changes in the socio-technical context, in order to create the most favorable conditions for the innovation. This was achieved by involving those actors that, directly or indirectly, could have affected regime practices and institutions, and by stimulating changes in their behaviors, attitudes and practices. For example, one of the identified contextual barriers for the introduction of the PSS was related to the local road regulation. In order to solve this problem, PSS promoters involved in the project the municipality of Cape Town to stimulate the Transport department to modify such regulation. Moreover the involvement of the transport department was also important to start

developing proposals for the integration of the PSS concept with the local suburban public transport system.

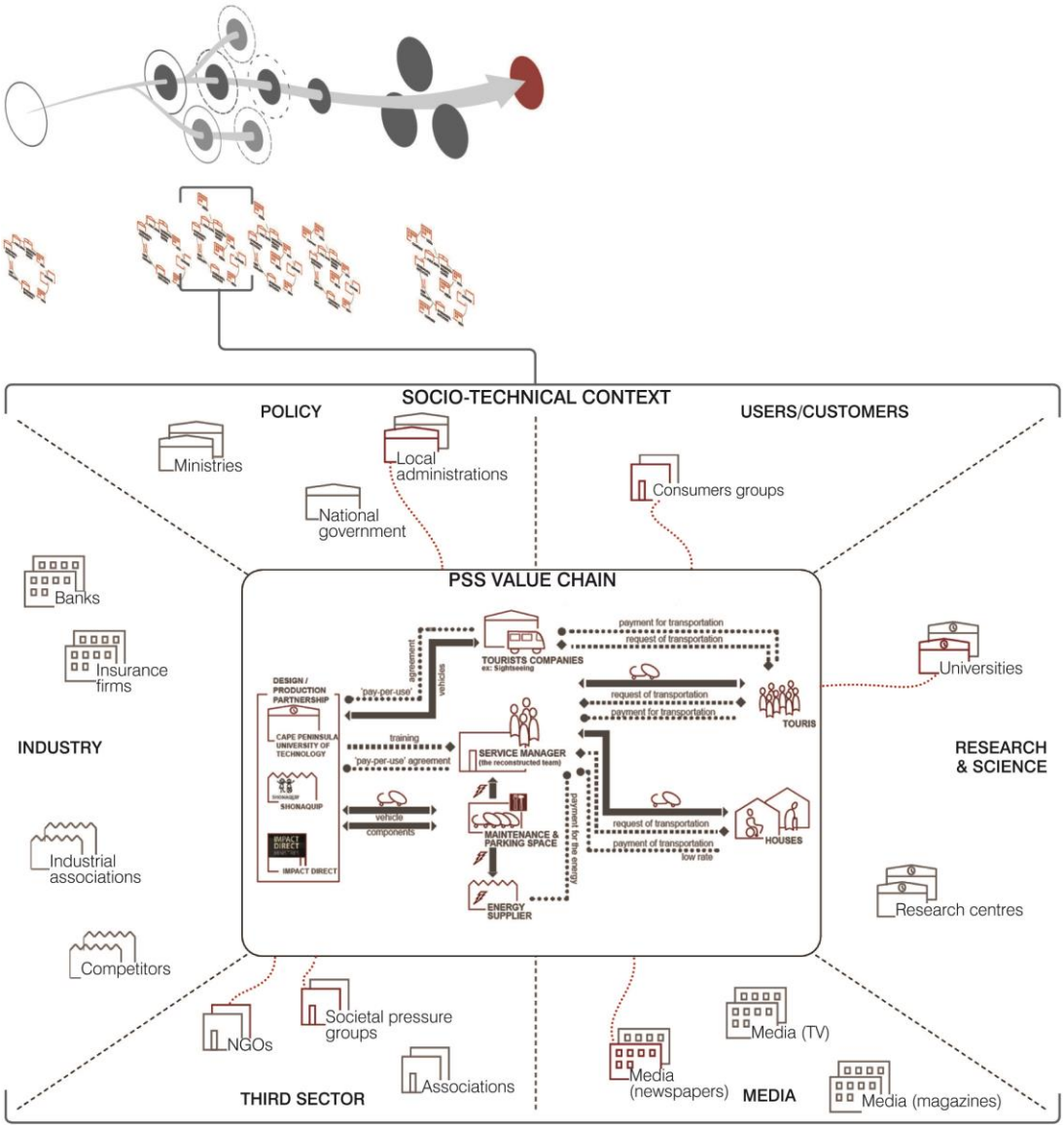
Figure 10: *A strategic attitude should be adopted in the designing and management of societal embedding processes. In this sense the transition path is aimed at influencing changes in the socio-technical context in order to create favorable conditions for the introduction and scaling up of the innovation (red arrows). (Reproduced from Ceschin 2012)*



Transition studies scholars suggest that establishing and developing a broad and heterogeneous socio-economic network is crucial to protect, support and foster radical innovations (Raven 2005). In particular it is crucial to involve outsiders and insiders actors (with respect to the dominant socio-technical regime): *outsiders* (e.g. outsider firms, scientists, societal pressure groups) are needed in a network because they do not share the current regime institutions and practices and therefore they may contribute in the development of innovations that deviate from that regime (Van de Poel 2000); *insiders* (e.g. policy makers, governmental institutions) should be involved because they can support and protect the innovation in the start-up phase (in order to give experiments legitimacy and stability) and in the subsequent phases (in order to create widespread support for scaling up the new practices and institutions related to those experiments) (Weber et al. 1999). In other words, it is required the involvement of a **broader network of actors** (Figure 11). This is what the project actors tried to do during the Cape Town Sustainable Mobility design experience. In fact, they focused not only on involving the actors that could have played a role in the value chain (Shonaquip, BEN Bikes, suppliers, users, etc.), but also on other relevant actors belonging to the socio-technical context in which the PSS was being introduced (NGOs such as DWDE, the Cape Town municipality, local media, etc.). In other words they focused on creating a broad network characterized by scientific, social, economic, politic and cultural linkages. Thus, when designing transition paths (and sequences of socio-technical experiments), it is crucial to involve those actors that can

start a bottom-up process of change, but also those actors that can create favorable conditions to protect and support the innovation through top-down processes.

Figure 11: *The actors involved in the process of transitioning are not only the ones that are more directly linked with the innovation (value chain), but also the ones that could have an influence in the socio-technical context. (Reproduced from Ceschin 2012)*

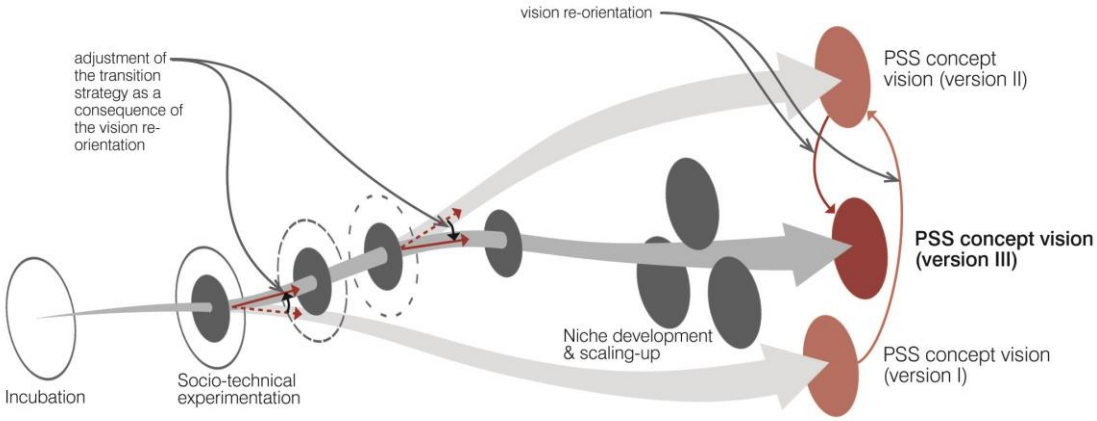


Finally, it is possible to say that the approach adopted in the project was characterized by a **dynamic design and management attitude** (Figure 12). The project vision was not a static outcome to be achieved; it was continuously adjusted as a result of changes in internal and contextual conditions and as a result of what was learnt by actors during the societal embedding process. For example, the defection of the Reconstructed Team led to the involvement of BEN Bikes in the project network, which in turn led to adjusting the project vision. Adjustments in the project vision led of course to modifications in the transition strategy. Even the network of actors

involved in the societal embedding process was dynamic: the composition, as well as the required tasks for each actor, continuously evolved in time. For example, the Cape Town municipality was involved only in the second phase of the societal embedding process, when institutional protection for the experiment was required.

In sum, in the project it was therefore crucial to adopt a flexible and dynamic approach. An open-ended approach (Hillgren et al. 2011) is required because of uncertainty, unpredictable events, changes in contextual conditions, and conflicting and alterable actors' expectations and views.

Figure 12: *A dynamic design and management attitude should be adopted. The project vision is not a static outcome to be achieved, and the transition strategy is not a fixed roadmap to be covered. Changes in internal and contextual factors, unpredictable events, learning process by project actors during the societal embedding process can lead to adjusting the project vision and, as a consequence, to re-orient the transition strategy. (Reproduced from Ceschin 2012)*



Based on the discussion above, it emerges that new strategic skills are required to design and manage the implementation and scaling-up of sustainable PSS innovation (Ceschin 2013b; Ceschin 2013c):

- **Translating the project vision into a transition strategy.** PSS designers should learn to translate a vision into the steps needed to support its implementation and scaling-up. In other words they must learn to design transition paths. Within these transition paths a crucial role is played by socio-technical experiments. PSS designers should therefore learn to design these kinds of experiments and in particular to design sequences of experiments capable to act as *labs*, *windows* and *agents of change*.
- **Identifying and involving a broad variety of actors** to support the societal embedding process. PSS designers should learn to identify the proper actors to be involved in the various phases of the process. Since the different phases of a transition path require different network compositions, PSS designers should be capable to design a dynamic network of actors: a network in which the composition, as well as the required tasks of each actor, continuously evolve in time. Moreover PSS designers should be capable of thinking not only about

the actors that could be part of the value chain, but also about the actors that could have the power and willingness to directly influence the dominant socio-technical regime. PSS designers should thus be able to act as *networkers* (capable of establishing bridges and links between different actors) and as *negotiator* (capable of managing controversies and conflicts within the network);

- **Facilitating the building up of a shared project vision and transition path**. PSS designers must learn to facilitate the strategic conversation between the actors involved, in order to develop (and adapt in time) a shared project vision and transition path. PSS designers should therefore be able to facilitate a participatory approach, involving a variety of stakeholders in discussing, negotiating, co-creating and developing alternatives. It is therefore crucial for them to be able to: organize the complexity of the information that must be exchanged and support effective communication activities among stakeholders; encourage and stimulate the various actors in taking part in strategic conversations; ensuring mutual understanding; and managing the diversity of their expectations as well as their negotiation and alignment. These skills are thus fundamental: being a *communicator* (capable of effectively illustrating complex information such as project visions and action plans) and a *facilitator* (capable of activating co-design processes and facilitating the convergence of actors' expectations);
- **Managing the dynamic adaptation of the societal embedding process.** PSS designers should learn to manage the continuous adaptation and evolution of the project vision, the transition path and the actor network. The societal embedding of an innovation should therefore be managed not as a project with a fixed outcome, but rather as an open search and learning process. Design, development, experimentation and implementation should be carried out simultaneously and in continuous interaction.

6 Concluding remarks

Sustainable PSS innovations represent a valuable concept for enhancing company competitiveness and at the same time providing environmental benefits. However, these innovations are in most cases radical, and their introduction and diffusion usually encounter the opposition of existing customers' habits, companies' organizational structures, and regulative frameworks. Hence, if immediately exposed to the mainstream market environment, it is highly probable they will not survive. An important challenge is therefore not only to conceive sustainable PSS concepts, but also to understand the contextual conditions in which they are introduced and explore the most suitable strategies and development pathways to embed these concepts in society.

This raises important questions on the role of design in addressing this challenge. The original contribution of this chapter is to build up synergies between concepts from two different research streams: the one on *PSS innovation*, and the one on *transition studies*.

Through an action research project the chapter has explored the integration of design thinking and transition studies in dealing with the societal embedding of PSS innovations. A crucial role is given to the implementation of sequences of socio-technical experiments, partially protected spaces where broad networks of actors incubate, test, develop and bring the innovation to maturity. Theoretical and empirical evidence supports the proposal that, in order to effectively contribute to transition processes, socio-technical experiments should be conceived as *Labs*, *Windows* and *Agents of Change.*

PSS designers could thereby play a role not only in generating sustainable PSS concepts, but also in designing transition paths to support and facilitate the introduction and scaling-up of the concept itself. To operate at such a level, new strategic skills are required by PSS designers and project managers.

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