The role of public policy in stimulating radical environmental impact reduction in the automotive sector: the need to focus on product-service system innovation

Fabrizio Ceschin* and Carlo Vezzoli

Politecnico di Milano, INDACO Department,
Unit of Research Design and System Innovation for Sustainability (DIS), via Durando 38/A, Milan, 20158, Italy
E-mail: fabrizio.ceschin@polimi.it E-mail: carlo.vezzoli@polimi.it
*Corresponding author

Abstract: Product-service system (PSS) innovation is a promising approach to address sustainability challenges in the automotive industry. Starting form this assumption, this paper presents and discusses the potential contribution that policy measures can have in fostering the automotive sector in innovating on a PSS level. A set of policy instruments (general instruments and specific PSS-targeted ones) are presented and classified, underlining the effects they could produce at the company and environmental levels. In order to effectively support sustainable PSS diffusion in the automotive industry, the paper suggests the integration of general policy measures (such as internalisation of external costs, extended producer responsibility programmes and informative policies), with the PSS-targeted ones (such as Green Public Procurement focused on sustainable PSS, support of companies in acquiring information related to PSS, support of demonstrative pilot projects). In addition, the paper suggests the necessity to involve actively universities and research centres.

Keywords: public policies; automotive industry; product-service system; PSS; sustainability; environmental impact reduction; functional economy; policy instruments; design; policy measures.

Reference to this paper should be made as follows: Ceschin, F. and Vezzoli, C. (2010) 'The role of public policy in stimulating radical environmental impact reduction in the automotive sector: the need to focus on product-service system innovation', *Int. J. Automotive Technology and Management*, Vol. 10, Nos. 2/3, pp.321–341.

Biographical notes: Fabrizio Ceschin works as a Researcher at the DIS research unit since 2006 inside the Design Department (INDACO) of Politecnico di Milano University dealing with innovation, design and development of products, services and systems targeting sustainable results. He is currently a PhD candidate in Design at Politecnico di Milano University, 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'. He co-authored the book *Method and Tools for Life Cycle Design. How to Design Low Environmental Impact Products*, Maggioli Editore.

Carlo Vezzoli is responsible of the Design and System Innovation for Sustainability (DIS) research unit inside the Design department (INDACO) of Politecnico di Milano University, and Professor of 'Design for environmental sustainability' and 'System design for sustainability' at Politecnico di Milano University. He coordinated several research projects and took part in EU funded researches (among which 'SusHouse, Sustainable House'; 'MEPSS, Methodology for Product-Service System Development'; 'HiCS, Highly Customerised Solutions'; 'SCORE!, Sustainable Consumption Research Exchange!'). He currently coordinates a national network of universities for curricula development on design for sustainability (LeNS.Italia) and the EU funded research 'LeNS, the Learning Network on Sustainability'. His most recent books are: *System Design for Sustainability. Theory, Method and Tools for a Sustainable Satisfaction-System Design*, Maggioli Editore, *Design for Environmental Sustainability*, Springer and *System Innovation for Sustainability*, Greenleaf.

1 Introduction: sustainability and the need to focus on radical changes

It is widely shared that the transition towards sustainability will require a radical redefinition of the current structures of production and consumption. Several studies in fact 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; World Business Council for Sustainable Development (WBCSD), 1996].

Given the dimension of the required change it is therefore clear that innovations on a product and technological level, although being fundamental and necessary, are not alone sufficient to obtain the just mentioned radical shift. In fact, although it is true that generally there is a continuous improvement of the environmental performance of products, it is also true that these improvements are often negatively counterbalanced by an increase in consumption levels. For instance, the environmental gain archived 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 [European Environmental Agency (EEA), 2008].

In addition, it has to be underlined that in the traditional production and consumption model, based on the production and sale of products, a producer's economic interest usually does not converge with an environmental interest in optimising the resources consumed [Mont, 2002; United Nations Environmental Programme (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 reducing a vehicles consumption in use nor in extending a cars 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 well-being. In this perspective, as suggested by Stahel (1988, 1997), 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 and technology are mere modes of providing functions (Mont, 2002). Functional economy is oriented to satisfy consumers through the delivery of functions instead of products (e.g., mobility instead of cars, having clean clothes instead of washing machines and powder) and this can potentially bring about a reduction in the current levels of resources consumption, without minimising consumers' level of satisfaction (UNEP, 2002; Tukker and Tischner, 2006; Mont, 2004).

Within this framework, it is considered promising to look at the concept of product-service system (PSS) innovation, understood as 'the result of an innovative strategy that shifts the centre of business from the design and sale of (physical) products alone, to the offer of product and service systems that are together able to satisfy a particular demand' (UNEP, 2002). In fact, if properly conceived, this kind of innovation can potentially bring companies to separating resource consumption from its traditional connection with profit; and, at the same time, find new profit centres to compete (and generate value and social quality) while decreasing (directly or indirectly) total resource consumption (Goedkoop et al., 1999; Brezet et al., 2001; Manzini and Vezzoli, 2001; UNEP, 2002; Tukker and Tischner, 2006; Mont, 2004). For this reason, in the last 15 years the European Union has dedicated special attention to this kind of innovations, funding several research projects[1], conferences and expert meetings[2].

Starting from these assumptions, the aim of this paper is to present and discuss the potential role of public policy in fostering radical environmental improvements (i.e., PSS innovation) in the automotive sector. The paper firstly focuses on explaining why PSS innovations can potentially contribute to stimulating radical environmental impact reduction in the automotive sector and what are the barriers that have to be faced when implementing such innovations. The paper will then discuss the potential contribution that policy measures can have in fostering the automotive sector in adopting a PSS approach. A set of policy instruments is presented and classified. Special attention is given to underlining the effects that these policies could produce at a company and environmental level, outlining the potential role that universities and research centres can have in collaborating with companies to support and facilitate the implementation of such policy measures (especially in relation to design activities).

The paper represents one of the outcomes of an ongoing research project denominated Vehicle Design Summit (VDS), run by an international consortium of universities coordinated by the Massachusetts Institute of Technology (MIT) of Boston. This research project is aimed at designing and prototyping an eco-efficient vehicle, defining an innovative and sustainable business model and exploring what the framework conditions is in order to facilitate the introduction and diffusion of this kind of innovation[3].

2 The automotive industry and PSS innovations

The automotive industry is characterised by a business model in which vehicle manufacturers represent the pivotal actor, directing both component suppliers and the distribution and retailing system (Wells, 2006); and their primarily source of profits is the sale of new vehicles. Within this model, vehicle producers – in order to increase profit margins – have adopted a strategy of mass production. This has brought about a high

volume output and high volume of sales to global market (Williams, 2006). The sector is characterised by a high breakeven point that acts as a barrier for the entry of new competitors into the market and moreover encourages the establishment of even larger global operations (Nieuwenhuis and Wells, 2003) and conservative design attitudes. This is why it is often less costly for a vehicle manufacturer to overproduce and oversupply newly produced cars than to cut back on manufacturing capacity (Williams, 2006). From an economical point of view, return to capital is low, typically below 5% and often negative with periodic crisis (Wells, 2006). The reason is that the overproduction leads companies to offer incentives in order to create increased demand and, therefore, as a result, we have a continuous discounting of the price of new cars and a consequential reduction of profit margins. What has to be underlined is that vehicle producers earn their profits mainly from the sale of cars and the spare parts, but they do not catch most of the earnings associated with the use of the vehicle. In fact, the automotive system of production and consumption is characterised by a variety of stakeholders and the profit generated by cars in use go mainly to fuel companies, independent garages and insurance companies (Wells and Nieuwenhuis, 2001). In other words, the current automotive business model is characterised by a lack of profitability (Nieuwenhuis and Wells, 2003; Williams, 2006; Wells, 2006).

Starting from these considerations, and from the assumption that incremental technological improvements alone cannot bring about radical environmental impact reductions, several authors have argued that PSS innovations represent a promising approach to combine economic and environmental sustainability in the automotive industry (Wells, 2006; Williams, 2006, 2007; Vezzoli and Ceschin, 2008a, 2008b).

As anticipated before, PSS innovation can be described as 'the result of an innovative strategy that shifts the centre of business from the design and sale of (physical) products alone, to the offer of product and service systems that are together able to satisfy a particular demand' (UNEP, 2002). In other words, a PSS innovation focuses on offering satisfaction rather than selling products and it can be described as an *integrated mix of products and services*, delivered by one or more *socio-economical actors* and capable to fulfil a given *demand of satisfaction* (in this case, 'having access to mobility'). It has to be underlined that PSSs are not sustainable per se, but have the potentiality, if conceived, implemented and managed in a proper way, to bring to radical environmental impact reductions (Goedkoop et al., 1999; UNEP, 2002).

The following text illustrates some examples of eco-efficient product-service systems (e-ePSSs) in the automotive industry, underlines the general potential benefits connected with these innovations and presents the main barriers for the implementation and diffusion of such innovations.

2.1 Examples of e-ePSS innovations in the automotive sector and their general characteristics

PSS innovation in the automotive industry is not a new concept; several cases of PSS (car leasing, car sharing and car pooling schemes, pay per service unit schemes and integrated mobility schemes, etc.) have been in fact implemented in the last years. These cases can be classified in three broad categories[4]:

- *Product-oriented services*: When products are still sold, but with some additional services (e.g., maintenance, repair, upgrading, substitution and product take back). In this case, the company is generally economically interested in optimising the product life span (e.g., facilitating maintenance, components reuse, material life extension, etc.). Examples related to the automotive sectors are (Williams, 2007): maintenance contracts or extended warranties on new cars; provision of spare parts/used components; provision of fuel/energy-efficiency information; traffic congestion information; and take back initiatives. This typology of PSS is the easiest to be implemented (small changes in companies organisation and users behaviour), but the potential environmental benefits are limited (Tukker and Tischner, 2006).

- *Use-oriented services*: Where service providers own the products and made them available to users, in different modalities (e.g., leasing, sharing, pooling). Usually in this case, the provider is economically interested in maximising the use of the product, in optimising its life span and in reducing the energy consumption in use, with consequent obvious benefits on environmental terms. Some examples:

  - *General Motor – EV1*. EV1, electric car produced by GM from 1996 to 1999 for the US market, was available only in a limited 'lease-only' agreement of three years. Service included maintenance (delivered by selected maintenance centres) and take back at the end of the contract. GM kept the ownership of the vehicles.

  - *Riversimple*, a small English transport company, is going to commercialise in 2010 a hydrogen vehicle, called 'Riversimple Urban Car', which will be available only with leasing agreements. Riversimple will keep the ownership of the car and clients will pay a fixed monthly sum, which includes the energy required to power the vehicle, insurance and all the needed maintenance and repairs. At the end of the contract, Riversimple will take back the vehicle (see http://www.riversimple.com).

  - *Move About – Th!nk*. Move About is a car sharing scheme for the general public in Oslo; the fleet of vehicles is made up of 40 electric cars, all from the Norwegian manufacturer Th!nk. Users pay a monthly membership fee plus an hourly rate (including everything from the insurance to the energy to move the vehicle). The local administration offers various incentives, like free parking, exemption from road pricing and authorisation to run in bus lanes[5].

- *Result-oriented services:* Where service provider and customer agree on a specific final results; companies offer a customised mix of services and maintain ownership of the products; and customer pays only for the provision of agreed results. Even in this case, the provider is economically interested in maximising the use of the product, in optimising its life span and in reducing the energy consumption in use. Some examples:

- *Liselec*, a car sharing/pay per service unit scheme. It is a partnership made up by La Rochelle local administration (France), VIA GT (a service transport company), Peugeot (which provides the electric vehicles) and Alcatel (which provides the electronic systems). Liselec offers a service of access to a fleet of electric cars. Users have a badge and pay per km covered and time of use; service includes the electric energy needed to power the vehicle, insurance, free parking spaces and discounts on the use of local public transports. The partnership keeps the ownership of the vehicles and is therefore responsible of maintenance, repair, upgrading and disposal[6].

- *Integrated mobility schemes*. The national German railway company Deutsche Bahn has explicitly declared its intention to provide the entire chain of mobility from 'house to house'. To do this Deutsche Bahn wants to integrate different transportation modes and with this aim an innovative mobility concept has been proposed: this model is based on an intermodal network between local and long distance public transport and other transport including, car-sharing, leasing, a chauffeur service and a bike sharing systems (Skinner et al., 2004).

Looking at this kind of innovation, it is possible to generalise and identify key common characteristics. Basically, rather than the 'traditional' forms of sales, ownership, consume and disposal of vehicles, a PSS innovation is focused on delivering a particular satisfaction, in this case, a service of 'access to mobility'; and this satisfaction is delivered through a mix of products (generally owned by the producers) and services. In general (but this depends on the specificity of each single case), three innovative elements can be underlined (Vezzoli and Ceschin, 2008a, 2008b):

- An *innovative stakeholders network*, including actors like energy supplier, insurance company, local administration and public transport company, which usually works autonomously within the supply chain; in this way, the stakeholders' fragmentation along the life cycle phases and the related indifference in system resources optimisation (present in the traditional business model), are avoided.

- A *shift from selling products to selling results*, meaning that it is not the vehicle and the fuel that are sold, but what it is offered is a service of 'access to mobility'. Users do not pay for the vehicle, the fuel, the spare parts, etc, but they pay per unit of 'satisfaction'.

- A *change in product and resources ownership*, in the sense that, differently from the traditional sale models, the partnership providing the PSS solution keeps the ownership of all the products that are part of the solutions (vehicle, fuel, etc.). As a consequence, the relationship between the producer and the user does not end after the transaction (as in the traditional business model), but continues in time.

2.2 Environmental benefits of e-ePSS innovations in the automotive sector

In the automotive traditional business model, car producer is economically interested in selling the greater amount of vehicles. Thus, it is not interested in extending as much as possible the car life span (on the contrary it is motivated in accelerating the replacement in order to increase sales). In addition, it is not economically incentivised in reducing the

car consumption (and the other running costs) in use. In other words, this is a business model in which the economic interests do not converge with the environmental ones.

As opposed to traditional business models, e-ePSS can potentially reward low resources consumption in use and product longevity (rather than obsolescence and high running costs). In fact, in these e-ePSS innovations, car producers (and the other stakeholders involved in the offer) are economically interested in (Wells, 2006; Williams, 2007; Vezzoli and Ceschin, 2008a):

- *Reducing the fuel/energy consumption in use:* In fact, if what is sold is a service of 'access to mobility' with a payment per unit of satisfaction (e.g., 'per km covered'), less energy is used by the vehicle per km, the costs will be minor and consequently the profits higher. In fact, in this case, the service includes the fuel/energy needed to move the vehicle and therefore the provider is motivated in reducing its consumption during use (e.g., introducing the most efficient motors/engines, reducing vehicle accelerations, adopting brake energy recovery systems, suggesting to drivers the shorter and less crowded travel route, etc.). And this is of key importance since the higher environmental impacts of a car are related to the use phase. This environmental potential benefits can usually be found in *user-oriented* and *result-oriented* services.

- *Extending vehicle life span:* Because if the producer maintains the ownership of the vehicle, it is economically motivated in postponing the disposal costs and the costs for the manufacturing of new vehicles. This environmental potential benefits can be found in *user-oriented* and *result-oriented* services (and in some particular *product-oriented* services).

- *Reusing and remanufacturing components:* For the same reasons explained before, producer is economically incentivised in postponing the disposal costs and the costs for the manufacturing of new components. Even in this case, the potential benefits are related to *user-oriented* and *result-oriented* services (and to some particular *product-oriented* services).

- *Extending materials life span*, through recycling and/or energy recovery, in order to avoid landfill costs and the costs of buying new materials. Even in this case, the potential benefits are related to *user-oriented* and *result-oriented* services (and to some particular *product-oriented* services).

In synthesis, if a PSS innovation is properly conceived, it is potentially capable of making profitability the consequence of a reduction in resource use and optimisation; it is therefore potentially capable of decoupling economic prosperity from the resources consumption.

2.3 Diffusion of PSS innovations in the automotive sector

To the potential environmental benefits connected to PSS innovation it has to be added that this kind of innovation can also bring benefits to the producer/provider (because they give the opportunity to differentiate the offer, extend in time the relationship with clients and in general improve the market and competitive position) and to the users (because

their needs can be satisfied in a more personalised way and because they are free from the problems linked to the product maintenance and disposal)[7].

For these reasons, several motor industries have started in recent years to differentiate their offers and, in addition to their traditional business, they have implemented various kinds of PSS solutions. For instance, *Honda*, in 1997, launched at their Motegi site in Japan the Intelligent Community Vehicle System, which allows employees to select electric vehicles for short-term rental (WBCSD, 2001); *GEM*, a subsidiary of *DaimlerChrysler*, implemented at Playa Vista, California, a mobility system based on a fleet of electric city cars available on a per-trip basis for residents and business tenants (Skinner et al., 2004); *Volvo*, in 1999, became involved with a car sharing scheme to serve industrial areas in Goteborg; *Renault*, together with the French energy agency ADEME and the Parisian urban transport authority, developed a car-sharing scheme denominated Caisse-Commune, in which users pay different rates depending on the distance of the journey, including fuel, insurance and maintenance (Caisse Commune, 2003).

Despite the proliferation of the number of innovative business models, the extent to which they provide the motor industry with a profitable business venture is at this point still very limited (Skinner et al., 2004). In fact, it has to be underlined that most of the innovative schemes implemented so far have been undertaken as pilot projects and their development and scaling-up, once the pilots expire, is still uncertain (ibid.).

In effect, even if the concept of PSS innovation has been deeply explored at the academic level[8] and even if it is recognised as a potential win-win solution (winning for the producers/providers, the users and the environment), the development and scaling-up of such innovations face different obstacles. This is because PSS innovations present some 'radical' characteristics that act as barrier for their implementation and diffusion. The most important of these barriers are (UNEP, 2002; Mont, 2002; Tukker and Tischner, 2006):

- *For companies*. Obviously, there is an organisational resistance in changing traditional ways of behaving: a PSS oriented business requires in fact a shift in corporate culture and market engagement. Moreover, adopting a PSS approach requires new design and management skills and despite the knowledge accumulated at the academic level (see for instance: Manzini et al., 2004; van Halen et al., 2005; Vezzoli, 2007), these skills are not widely diffused within firms and consultancy companies. As a consequence, there could be a lengthening of the time to market in the implementation of PSS solutions. In addition, there could be uncertainties about cash flows, because these are usually linked to a medium-long-term investment.

- *For users*. Although ownerless consumption can potentially offer many benefits to users, the main barrier is just the difficult in gaining customer acceptance about ownerless solutions. This is true especially in B2C markets (Mont, 2002) and especially for user-oriented and result-oriented services. Product-oriented services, like car leasing, are accepted and relatively diffused (because they require little changes in user's behaviour) but, as underlined before, these services have limited environmental benefits (and, in some cases, can even determine negative ones)[9]. In addition, another barrier is the lack of knowledge about life cycle costs and this creates a problem in understanding the potential economic benefits of a PSS oriented solutions.

- *For governments*. Actual laws may not favour PSS oriented solutions. In addition, there are difficulties in implementing policies to create corporate drivers to facilitate the promotion and diffusion of this kind of innovation.

3 Policy measures for PSS innovations in the automotive industry

It has been argued that PSS innovations represent a promising approach to sustainability also for the automotive industry (potentially winning for companies, users and the environment), but at the same time, there are several barriers that act as obstacles for the implementation and diffusion of such innovations.

For these reasons, it is clear that there is a potential role for governments to intervene, developing policy frameworks and proper conditions that would stimulate the introduction and diffusion of e-ePSS innovations. In this sense, the assumption is that governments should intervene in orienting the market towards the directions that could bring benefits to society. The main reason to justify the need for government intervention is related to so-called externalities. Externalities are environmental impacts that are not included in market prices; for instance in the automotive sector, the environmental and health costs related to the use of gasoline are not included in the gasoline or in the car price and therefore car producers do not have any incentive to take into account the effects determined by its use. For this reason, as underlined by Cleff and Rennings (1999), government intervention is required to implement policy measures capable of internalising externalities and, as a consequence, stimulate environmental innovation. Generally speaking, this aim can be targeted at adopting pollution charges and fiscal incentives for pollution abatement, but also using market signals (e.g., eco-labelling, green rates, etc.) and facilitating the dissemination of knowledge and information about environmental innovations to firms and consultancy companies.

The problem is that, as we have underlined before, these policy measures should not (or at least not only) focus on the environmental improvement of products and technologies, but especially on stimulating PSS innovation. And it is therefore clear that, as underlined by Mont (2001), traditional policy instruments targeting product environmental performances are not sufficient to reach this aim. In fact, even if instruments such as *eco-labelling* and *Environmental Product Declarations* (*EPD*) can stimulate companies in 'greening' their products and give users the possibility to select the best option to buy, on the other hand, these instruments still promote a consumption based on individual product ownership; in other words 'they provide no alternatives to the existing consumption system' (ibid.), based on the production and sale of material products.

For this reason, governments should intervene implementing policy measures capable (directly or indirectly), to stimulate the diffusion of e-ePSS innovations. In this sense, three main directions of actions can be identified:

- *Creating the economical conditions* to encourage companies in shifting their business models towards a PSS approach. Sustainable PSS innovations usually cannot compete with traditional solutions if external costs are not internalised (Mont and Lindhqvist, 2003). This, together with the fact that PSS innovations are linked to medium-long term investments and uncertainties related to cash flows, should bring

governments to operate in order to overcome these barriers and make e-ePSSs economically viable.

- *Raising consumers' awareness* to inform users about the benefits brought about by e-ePSS innovations and in this way stimulate and support the shift towards ownerless consumption.
- Supporting *information and knowledge dissemination to companies*. Since one of the main barriers of the implementation and diffusion of sustainable PSS innovations is related to the lack of knowledge within firms and consultancy companies, governments should act on the dissemination of information about: the general concept of PSS, successful case studies of PSS in the automotive sector, but also methods and tools to design and implement such innovations. This should be coupled with the dissemination of knowledge about the low profitability of the traditional automotive business model.

In other words, governments should intervene assuming a wider approach, focusing on creating the background conditions to enable companies in adopting a PSS approach (providing them information and knowledge and implementing a proper economical framework) and enable users in accepting such kinds of solutions. In this sense, a set of policy instruments can be identified. We can divide them in: *regulatory,* including actions aiming at modifying agents' behaviour by defining or changing sets of rules (e.g., restrictions, standards and controls) (Vieira et al., 2007); *economic*, including actions aiming at modifying agents' behaviour through a market-based approach (ibid.); *informative*, including actions aiming at disseminating knowledge to agents (e.g., companies, consumers).

The following text presents the identified instruments, classifying them in 'general policy measures indirectly addressing PSS' and 'specific PSS-oriented policy measures'. The first ones refer to policies defined to address environmental problems without necessarily steering directly towards the development of PSSs; the second ones refer to policies oriented directly at stimulating the introduction and diffusion of e-ePSSs.

Each instrument is described illustrating the potential environmental benefits and the effects produced at the company level. Moreover, it will be underlined that the potential role universities and research centres (especially the ones related to design) can have in supporting such policy measures. In fact, the assumption is that these institutions can play a key and active role in stimulating, promoting and facilitating e-ePSS innovations (see for example the Riversimple case, described in Section 2.2, in which Cranfield University is a strategic partner; or the VDS project[10], coordinated by MIT of Boston).

At the end of the section, two summarising tables are provided.

3.1 General policy measures indirectly addressing PSS

They include: 'internalisation of environmental external costs, extended producer responsibility (EPR) programme' and 'informative policies aimed at increasing consumer awareness'.

The *internalisation of environmental external costs* is a policy tool aimed at internalising the market prices of products or services into the related environmental externalities. For instance: including in the market price of gasoline the environmental costs derived from its use, or including in the car price the environmental costs related to

its disposal. Actions that can be implemented by governments in this direction are: pollution charges or taxes based on output/input of polluting units, fiscal incentives for pollution abatement.

These actions can potentially reward better environmental alternatives, stimulate companies in adopting solutions with higher environmental performances and make products and solutions with lower environmental characteristics not economically viable. In other words, the aim is to create economical conditions that protect and favour low environmental impact solutions.

Depending on what they target, these measures can have different influences at the company level (for instance regulations on emissions standards can steer car producers in realising low emissions vehicles, while regulations on the end of life can bring a company to designing products that are easier to recycle, etc.). However, it is clear that these measures will not necessarily orient a company towards the adoption of a PSS approach but only favour the better environmental alternatives (sifting out products and solution with low environmental qualities).

The problem related to this kind of measure is that, as underlined by Mont and Lindhqvist (2003), the introduction of proper environmental taxes is in several cases not feasible, due to inadequate knowledge of external costs and due to insufficient political support.

Since the implementation of such measures stimulates companies in producing cars with low environmental impacts, it is therefore clear that universities and research centres could potentially play an active role in relation to this. In particular, they could provide support to companies in product Life Cycle Design (LCD) activities. This topic has been deeply explored at the academic level and, from the operative point of view, several methods and tools have been developed to orient the design process towards the definition of low environmental impact products (see for example Tischner et al., 2000; Vezzoli and Manzini, 2008; Vezzoli et al., 2009).

EPR programmes represent a specific way to internalise environmental externalities and consists of a set of measures to push producers to take responsibility for the costs related to the management of their products at the end of life. This can take the form of product take back, recovery and recycling, or depollution treatments. As a direct consequence, producers have an incentive to minimise the costs associated with the end of life.

As a result, this kind of measure may lead to the optimisation of the end-of-life environmental impacts. In fact car producers might be motivated in designing products that are easier to refurbish and recycle after the use phase (Williams, 2007). Moreover, producers are also potentially stimulated in adopting a PSS oriented approach. In fact, producers might be motivated in thinking in terms of PSS design, for example defining strategic partnerships with disposal centres, or implementing take back services in collaboration with local dealers. Furthermore, EPR programmes could be also a driver for companies to test innovative business models based on the retention of car ownership.

However, as underlined by Tojo (2001), if we look at the practical application of these measures, it is clear that they do not produce innovations on a PSS level; the EPR principle has often been translated into practical application that focus primarily on end-of-life stages, with the best scenario provided if EOL requirements are taken into consideration in product design. This is what happened with the EC directive End-Of-Life Regulations, in which the producer responsibility is related to a limit in the

use of hazardous substances in vehicle production, designing more recyclable vehicles, integrating more recycled materials into new vehicles, and providing dismantling information to disposal centres and covering costs of take back and treatment. In other words, this directive is pushing producers to improve vehicles life cycle impacts, but in effect, it is not directly stimulating the adoption of PSS oriented solutions.

In addition, it has to be remarked that EPR programmes usually focus on the end-of-life, but if we look at the life cycle impact of a car, then the impact related to the disposal phase is quite irrelevant if compared to the impacts due the use phase (SustainAbility and UNEP, 2001). For this reason, EPR programmes, in order to be environmentally effective, should also focus on extending producer responsibility to the use phase of vehicles.

Regarding the potential contribution of universities and research centres, in addition to providing support to product LCD activities (as mentioned before), there is also the opportunity to support design activities at a system level, that is to say that the design of the system configuration: which are the stakeholders and which are their interactions (e.g., the design of the interaction between the different stakeholders involved in the take back service and in the car treatment). In relation to this, methods and tools have been recently developed at the academic level (see Manzini et al., 2004; van Halen et al., 2005; Vezzoli, 2007) and the related knowledge can be transferred to companies.

Informative policies can be implemented in order to increase consumer awareness. The aim of this kind of measures (such as eco-labelling, consumer advice, consumer campaigns) is to inform users about environmentally preferable solutions available in the market. Informative policies could be also used to disseminate the concept of e-ePSS to users, in order to make them aware of the potential environmental benefits connected to this kind of solutions and, at the same time, favour and support their acceptance towards a consumption not based on material products ownership.

Since governmental institutions, as argued by Mont and Lindhqvist (2003), can lack the tools to understand what solutions have the lowest environmental impacts and can lack general knowledge about PSS, universities and research centres can act to provide support in this direction (e.g., support governments in collecting and disseminating information about successful e-ePSS examples).

Companies involved in environmental innovation can be favoured and encouraged by these measures, while companies linked to environmentally inferior solutions might be motivated in modify their products and services.

3.2 Specific PSS-oriented policy measures

The just mentioned policy measures can potentially set some background conditions to promote environmentally preferable solutions and discourage environmentally inferior products and services. But these measures will not necessarily result in companies to develop e-ePSS innovations.

For this reason, these policy measures should be integrated with specific ones, capable of fostering directly e-ePSS innovations. This set of policies includes: Green Public Procurement (GPP) focused on e-ePSS; incentivise companies in acquiring information related to PSS; disseminate to companies information related to e-ePSS; support the generation of professionals capable of designing, implementing and managing e-ePSS; and support demonstrative pilot projects.

Public institutions should focus GPP also on e-ePSS innovations; in other words, they should include e-ePSS solutions in their purchase guidelines and prefer them before product sales. As suggested by Larsen and Svane (2005) and Tukker et al. (2008), GPP is considered as one of the key policies that could be used to promote the change of unsustainable patterns of consumption and production.

Examples of GPP initiatives that could be undertaken by public institutions are: instead of purchasing a fleet of cars, make an agreement with an automotive firm to have vehicles leased (including maintenance, fuel/energy); or make an agreement with local car-sharing services. As a result, car producers might be stimulated in experimenting innovative e-ePSS oriented solutions. In addition, through these innovative initiatives, car producers have also the opportunity to verify user acceptance and technological availability; in other words, they can learn about the feasibility of their PSS offers and understand which elements of the solution need to be improved.

Moreover, governments should also incentivise companies in adopting GPP initiatives focused on PSS. For instance, the Greater Copenhagen Authority has set up an office to help private companies to set up mobility plans for their employees, linking existing car-sharing and car-pooling schemes (Skinner et al., 2004).

Since not all PSS innovations are sustainable (Goedkoop et al., 1999; UNEP, 2002), universities and research centres can support public institutions in selecting the environmentally better solutions to be favoured.

GPP can stimulate companies in focusing on e-ePSS innovations, but these measures do not overcome the barriers related to the general lack of knowledge on PSS within companies. For this reason, in addition to GPP initiatives, governments should also take action on disseminating to companies information and know-how related to e-ePSS.

Since, as it has been said before, knowledge and experience about e-ePSS innovations has been accumulated at the academic level, governments should act involving universities and research centres in collecting information about e-ePSS innovations in the automotive sector and facilitating the consequential dissemination to companies. In fact, as underlined by Mont (2004), changes in companies demand thoroughly analysed examples of deliberately designed PSSs, because many companies are not at the forefront of the research.

In addition, companies require the acquisition of an operative approach, method and tools to design and implement e-ePSS innovation and also the skills and competencies to evaluate PSS from the environmental point of view (during and at the end of the development process). The dissemination of information related to these issues could increase the level of knowledge in car producers, and encourage them to follow this innovation path.

In addition governments should act incentivising companies in acquiring information related to e-ePSS; for example, supporting economically collaboration projects between companies and universities/research centres.

Acting on a more strategic level, governments should also support the generation of professionals capable of designing, implementing and managing e-ePSS. In this perspective, universities and research centres could play a key role in training professionals (designers, technicians, managers, etc.) on the topics of e-ePSS, in order to make them capable to effectively contribute to a transition towards a sustainable society[11].

Although the dissemination of information related to e-ePSSs is important, it is probably of higher importance to support demonstrative pilot projects aimed at wider diffusion of e-ePSS solutions. In this sense, governments should define programmes of experimentation to support car producers in designing, implementing and testing sustainable PSS solutions.

We can define these pilot projects as *niche innovations*, 'spaces' or 'locations' that are protected from the dominant socio-technical regime and in which actors develop and apply an innovation without immediate or direct pressure from the existing regime (Kemp et al., 1998). Several authors argue that niches and niche markets are a fundamental part of transitions; niches can be special geographical locations but also specific application domains, which act as stepping stones for learning and wider diffusion (Kemp et al., 1998, 2001; Raven, 2005; Caniëls and Romijn, 2006). Niche innovations are fostered by a network of stakeholders and its formation and development revolves around experimentations in which actors learn about: the technological and environmental possibilities and constraints of the innovation; the discovery of specific application domains; the acceptability by users, social groups and stakeholders; suitable policies to regulate or promote the innovation (Kemp et al., 2001; Vezzoli et al., 2008).

If oriented towards the experimentations of sustainable PSSs, these pilot projects can potentially give the opportunity to car producers to test new and promising business models (without a direct market pressure) and learn about technological feasibility and user acceptance. Governments should stimulate the initiation and the protection (for example, with investment grants, tax exemptions, etc.) of this kind of niche innovations, in order to gain momentum for a potential diffusion and scaling-up.

An example of this kind of pilot project is the previously mentioned *Liselec*, an innovative car sharing system involving La Rochelle local administration (France), VIA GT, Peugeot and Alcatel. The pilot project begun in 1999, thanks to public funding and, in 2003, in response to the positive feedback from customers, the authorities in La Rochelle have decided to expand the scheme (Skinner et al., 2004). Another pilot project started thanks to public funding is *Praxitéle* (a partnership made up by Saint-Quentin-en-Yvelines local administration – France, the local public transport company, Renault and Electricité de France), which offers a service of access to a fleet of electric cars; users have a badge and pay per km covered and time of use and service includes the electric energy, maintenance, insurance, free parking spaces and discounts on the use of local public transports (Vezzoli and Ceschin, 2008b).

In addition to giving companies the opportunity of direct learning about PSSs (their design, implementation and management), these pilot projects can also act as a 'window' to give visibility to the companies and the e-ePSS innovations themselves. This could represent a stimulus for other companies to follow this innovation direction.

In these kinds of pilot projects, it is clear that a strong involvement of universities and research centres is of vital importance. In particular, they could have a role in supporting companies in designing sustainable PSS solutions and in implementing and managing pilot projects. In this way, through practical experiences, there is the opportunity for car producers not only to acquire information and knowledge about e-ePSSs, but also to apply and test this knowledge in real projects. For this reason, governments should not only encourage and support these demonstration projects, but also facilitate the involvement of universities and research centres.

Table 1 General policy measures: their objectives, potential effects on the company and environmental levels and potential role of universities and research centres

General policy measures					
Objective addressed			*Potential effects*		
Create the economical conditions to stimulate companies in developing PSS solutions	*Support knowledge dissemination about PSS to companies*	*Raise consumers' awareness about PSS*	*Company level*	*Environmental level*	*Role of university and research centres related to design*
Internalisation of external costs					
Internalisation of environmental costs through: pollution charges or taxes, fiscal incentives			Companies should design vehicles with lower environmental impact optimising the life cycle impacts	Optimisation of vehicles life cycle environmental impacts	Support companies in life cycle design activities
EPR programmes					
Measures to push producers to take responsibility of the costs related to the end of life of vehicles			Companies are stimulated in developing solutions related to: product take back, recovery and recycling, depollution treatments	Optimisation of vehicles life cycle environmental impacts	Support companies in designing products that are easier to disassemble, refurbish or recycle after the use phase; support in designing take back and recovery services
Informative policies					
		Eco-labelling, consumer advices, consumer campaigns, to inform users about the environmentally better solutions	Companies are stimulated in developing low environmental impact solutions	Higher demand of low environmental impact solutions	Support governments in individuating the solutions with lower environmental impact

Table 2 PSS-targeted policy measures: their objectives, potential effects on the company and environmental levels and potential role of universities and research centres

PSS-oriented policy measures					
Objective addressed			*Potential effects*		*Role of university and research centres related to design*
Create the economical conditions to stimulate companies in developing PSS solutions	*Support knowledge dissemination about PSS to companies*	*Raise consumers' awareness about PSS*	*Company level*	*Environmental level*	
GPP focused on sustainable PSS					
Include e-ePSS solutions in public administration's purchase guidelines			Companies are stimulated in developing and testing innovative PSS-oriented solutions	Implementation and potential diffusion of e-ePSS solutions	Support government in individuating the PSS solutions with lower environmental impact
Support companies in acquiring information related to sustainable PSS					
	Overcome the barrier related to the general lack of knowledge about PSS within companies		Acquisition of knowledge about the concept of e-ePSS; how to design, implement and manage such innovations	Implementation and potential diffusion of e-ePSS solutions	Collect information about e-ePSS and facilitate the consequent dissemination to companies
Support the generation of professionals capable of designing, implementing and managing e-ePSSs					
	Overcome the barrier related to the general lack of knowledge about PSS within companies		Acquisition of knowledge about the concept of e-ePSS; how to design, implement and manage such innovations		Train professionals (designers, technicians, managers, etc.) on the topics of e-ePSSs
Support demonstrative pilot projects related to e-ePSSs					
Incentivise the development of pilot projects (public funding, fiscal incentives)	Pilot projects give to companies the opportunity of a direct learning about PSSs	Pilot projects can potentially stimulate new consumers' behaviours	Companies are stimulated in developing and testing innovative PSS-oriented solutions	Implementation and potential diffusion of e-ePSS solutions	Support companies in designing sustainable PSS solutions and in implementing and managing pilot projects

3.3 Discussion

General policy measures, such as *internalisation of external costs*, *EPR programmes* and *informative policies*, have the potentiality to set up the economical framework conditions to encourage environmentally better products and services and sift out environmentally inferior solutions (see Table 1). But these measures do not necessarily steer companies towards the development of PSS-oriented innovations.

For this reason, these policies should be accompanied by targeted policy measures, capable of stimulating and incentivising car producers in designing and implementing sustainable PSS-oriented solutions. In this sense, some potential initiatives that could be undertaken by governments are: GPP focused on sustainable PSS, support companies in acquiring information related to sustainable PSS, support the generation of professionals capable of designing, implementing and managing e-ePSS and support demonstrative pilot projects (see Table 1).

In other words, it is suggested to integrate general measures (capable to set up the framework conditions to potentially favour sustainable PSS innovation), with specific PSS-oriented measures (capable to enable and stimulate companies in the development of business models based on sustainable PSS).

The involvement of universities and research centres (especially the ones related to design) is of key importance in supporting knowledge transfer to companies. In fact, since the concept of e-ePSS has been deeply explored at the academic level (several methods and tools have been developed to support the design, implementation and management of sustainable PSSs), it is quite obvious that research centres could play an important role in disseminating to companies knowledge and information about PSSs, and also support them in setting up, implementing and managing pilot projects related to sustainable PSS innovations.

4 Conclusions

This paper has argued that PSS innovation is a promising approach to addressing sustainability challenges in the automotive sector. In fact, as opposed to the traditional business models based on the production and sale of vehicles, a PSS innovation is potentially capable to match the economic interests of car producers (and of the other stakeholders involved in the offer), with the environmental interests of optimising (even radically) the consumption of resources.

Several examples of promising e-ePSSs have been implemented by car producers in the last years despite the limited diffusion of this kind of innovation. In fact, the development and scaling-up of such innovations face several barriers (obstacles on the company, user and government levels).

For these reasons, there is a potential role for governments to intervene, developing policy frameworks and proper conditions that would stimulate the introduction and diffusion of PSS innovations. In this sense, three main directions can be identified

1 create the economical conditions to encourage companies in shifting their business towards a PSS approach

2 support dissemination of knowledge about PSS to companies

3 raise consumer awareness.

Starting from these assumptions, the paper identified a set of *general policy measure* (internalisation of external costs, EPR programmes and informative policies), potentially capable of setting the background conditions to favour environmentally beneficial solutions and specific PSS-oriented policy measures (GPP focused on sustainable PSS; support companies in acquiring information related to sustainable PSS; support the generation of professionals capable of designing, implementing and managing e-ePSSs; support demonstrative pilot projects) potentially capable of stimulating and incentivising car producers in designing and implementing sustainable PSS-oriented solutions.

In order to effectively support sustainable PSS diffusion in the automotive industry, it is suggested to integrate general policy measures with the PSS-oriented ones. In addition, it is suggested to involve universities and research centres to support companies in acquiring (and putting in practice) knowledge about the design, implementation and management of sustainable PSSs.

Acknowledgements

The paper is the result of the collaboration between the two authors; nevertheless Ceschin wrote Sections 1, 2 (introductive part) and 3 (except Section 3.3); Vezzoli wrote Sections 2.1, 2.2, 2.3, 3.3 and 4.

References

Baines, T.S., Lightfoot, H., Williams, G.M. and Greenough, R. (2006) 'State-of-the-art in lean design engineering: a literature review on white collar lean', *Journal of Engineering Manufacture*, *Proc. IMechE*, Part B, Vol. 220.

Brezet, H., Diehl, J.C. and Silvester, S. (2001) 'From ecodesign of products to sustainable systems design: Delft's experiences', *Environmentally Conscious Design and Inverse Manufacturing*, *Proceedings EcoDesign 2001: Second International Symposium*, pp.605–612.

Caisse Commune (2003) Available at http://www.caisse-commune.com.

Caniëls, M. and Romijn, H. (2006) 'Strategic niche management as an operational tool for sustainable innovation: guidelines for practice', *Schumpeter Conference 2006*, Nice, France, 21–24 June.

Cleff, T. and Rennings, K. (1999) 'Determinants of environmental product and process innovation', *European Environment, Special Issue: Integrated Product Policy and the Environment*, Vol. 9, No. 5, pp.191–201.

European Environmental Agency (EEA) (2008) 'Beyond transport policy – exploring and managing the external drivers of transport demand. Illustrative case studies from Europe', EEA Technical Report No. 12/2008.

Factor 10 Club (1994) 'Declaration of the Factor 10 Club', available at http://www.techfak.unibielefeld.de/techfak/persons/walter/f10/declaration94.html.

Goedkoop, M.J., van Halen, C.J.G., te Riele, H.R.M. and Rommens, P.J.M. (1999) *Product Service Systems, Ecological and Economic Basis*, PricewaterhouseCoopers N.V./Pi!MC, Storrm C.S., Preconsultants.

Kemp, R., Rip, A. and Schot, J. (2001) 'Constructing transition paths through the management of niches', in R. Garud and P. Karnøe (Eds.): *Path Dependence and Creation*, pp.269–299, Lawrence Erlbaum, London.

Kemp, R., Schot, J. and Hoogma, R. (1998) 'Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management', *Technology Analysis & Strategic Management*, Vol. 10, No. 2, pp.175–195.

Larsen, K. and Svane, Ö. (2005) 'Routines and communities of practice in public environmental procurement processes', CESIS Electronic Working Paper Series, Paper No. 44.

Manzini, E. and Vezzoli, C. (2001) 'Strategic design for sustainability', paper presented in *TSPD Conference*, Amsterdam, The Netherlands.

Manzini, E., Collina, L. and Evans, S. (2004) *Solution Oriented Partnership*, Cranfield, Cranfield University.

Mont, O. (2001) 'Reaching sustainable consumption through the concept of a product-service system (PSS)', Coprnhagen, Nordic Council of Ministers, TemaNord.

Mont, O. (2002) 'Clarifying the concept of product-service system', *Journal of Cleaner Production*, Vol. 10, No. 3.

Mont, O. (2004) 'Product-service systems: panacea or myth?', Doctoral dissertation, IIIEE Lund University.

Mont, O. and Lindhqvist, T. (2003) 'The role of public policy in advancement of product service systems', *Journal of Cleaner Production*, Vol. 11, No. 8.

Nieuwenhuis, P. and Wells, P. (2003) *The Automotive Industry and the Environment*, Woodhead Publishing Limited/CRC Press LLC, Cambridge England/Boca Raton, FL, USA.

Raven, R.P.J.M. (2005) 'Strategic niche management for biomass. A comparative study on the experimental introduction of bioenergy technologies in the Netherlands and Denmark, PhD thesis, Eindhoven University of Technology, Eindhoven, The Netherlands.

Schmidt-Bleek, F. (1996) *MIPS Book or the Fossil Makers – Factor 10 and More*, Berlin, Boston, Basel.

Skinner, I., Haines, D., Senft, L., Bowyer, C. and Fergusson, M. (2004) 'Mobility services: setting the policy framework – first year project report: a review of experiences', Institute for European Environmental Policy, available at http://www.carplus.org.uk/Resources/pdf/IEEP_Review_Mobility_Services04.pdf.

Stahel, W.R. (1988) *The Limits to Certainty: Facing Risks in the New Service Economy*, Dordrecht, Kluwer Academic Publishers.

Stahel, W.R. (1997) *The Functional Economy: Cultural and Organisational Change, from the Industrial Green Game: Implications for Environmental Design and Management*, National Academy Press, Washington, DC.

SustainAbility and United Nations Environment Programme (UNEP) (2001) *Driving Sustainability – Can the Auto Sector Deliver Sustainable Mobility*, Paris, France.

Tischner, U., Schmincke, E., Rubik, F. and Prosler, M. (2000) 'How to do ecodesign?: A guide for environmentally and economically sound design', German Federal Environmental Agency.

Tojo, N. (2001) 'Effectiveness of EPR programme in design change. Study of the factors that affect the Swedish and Japanese EEE and automobile manufacturers', Research project for Stiftelsen Svenskt Kretslopp, IIEEE, Lund University, Lund.

Tukker, A. and Tischner, U. (2006) *New Business for Old Europe. Product Services, Sustainability and Competitiveness*, Sheffield, Greenleaf Publishers.

Tukker, A., Emmert, S., Charter, M., Vezzoli, C., Sto, E., Andersen, M.M., Geerken, T., Tischner, U. and Lahlou, S. (2008) 'Fostering change to sustainable consumption and production: an evidence based view', *Journal of Cleaner Production*, Vol. 16, pp.1218–1225.

United Nations Environmental Programme (UNEP) (2002) 'Product-service systems and sustainability. Opportunities for sustainable solutions', UNEP, Paris.

van Halen, C., Vezzoli, C. and Wimmer, R. (2005) *Methodology for Product Service System. How to Develop Clean, Clever and Competitive Strategies in Companies*, Assen, Van Gorcum.

Vezzoli, C. (2007) *System Design for Sustainability. Theory, Methods and Tools for a Sustainable 'Satisfaction-System' Design*, Maggioli Editore, Rimini.

Vezzoli, C. and Ceschin, F. (2008a) 'Product Service Systems in the automotive industry: an alternative business model for a sustainable satisfaction system', in K. Cheng, H. Makatsoris and D. Harrison (Eds.): *Advances in Manufacturing Technology*, Vol. 22, *Proceedings of the sixth International Conference on Manufacturing Research (ICMR08)*, Brunel University, Uxbridge, UK, 9–11 September.

Vezzoli, C. and Ceschin, F. (2008b) 'Modelli di business alternativi per l'industria automobilistica', *Trasporti & Cultura*, Vol. 21, Campanotto Editore.

Vezzoli, C. and Manzini, E. (2008) *Design for Environmental Sustainability*, Springer, London.

Vezzoli, C., Ceschin, F. and Cortesi, S. (2009) *Metodi e Strumenti per il Life Cycle Design. Come Progettare Prodotti a Basso Impatto Ambientale*, Maggioli Editore, Rimini.

Vezzoli, C., Ceschin, F. and Kemp, R. (2008) 'Designing transition paths for the diffusion of sustainable system innovations. A new potential role for design in transition management?', in C. Cipolla and P.P. Peruccio (Eds.): *Changing the Change. Design, Visions, Proposals and Tools*, Umberto Allemandi, Torino, *C. Proceedings della Conferenza 'Changing the Change'*, Torino, Italia, 10–12 July, pp.1–14, available at http://www.allemandi.com/cp/ctc.

Vieira, J., Moura, F. and Viegas, J.M. (2007) 'Transport policy and environmental impacts: the importance of multi-instrumentality in policy integration', *Transport Policy*, Vol. 14.

Wells, P. (2006) 'Alternative business model for a sustainable automotive industry', *Proceedings Perspectives on Radical Changes to Sustainable Consumption and Production (SCP), SCORE! Network*, Copenhagen.

Wells, P. and Nieuwenhuis, P. (2001) *The Automotive Industry – A Guide*, CAIR, Cardiff, UK.

Williams, A. (2006) 'Product service-systems in the automotive industry: a case for micro-factory retailing', *Journal of Cleaner Production*, Vol. 14, No. 2, pp.172–184.

Williams, A. (2007) 'Product service-systems in the automotive industry: contribution to system innovation?', *Journal of Cleaner Production*, Vol. 15, Nos. 11–12, pp.1093–1103.

World Business Council for Sustainable Development (WBCSD) (1996) 'Eco-efficient leadership', Final report of the Working Group on eco-efficiency.

World Business Council for Sustainable Development (WBCSD) (2001) 'Mobility 2001: world mobility at the end of the twentieth century and its sustainability', World Business Council for Sustainable Development, Geneva.

Notes

1 For instance, Product and Service Co-Design Process (PROSECCO), Highly Costumerized Solutions (HiCS) (Manzini et al., 2004) and Method for PSS Development (MEPSS) (van Halen et al., 2005).

2 For example, see the recent workshop 'Business models with environmental effects', organised by the European Commission – Sustainable Development and Economic Analysis unit.

3 For further information about the VDS project see Vezzoli and Ceschin (2008a).

4 The literature on PSS proposed different classifications of the PSS typologies (Baines et al., 2006), most of them distinguish between three categories: product-oriented services; use-oriented services and result-oriented services. In relation to the different types of PSSs in the automotive industry, see Williams (2007) for an extensive description.

5 See http://www.mindsinmotion.net/index.php/mimv34/themes/hybrid_electric/featured/move_about.

6 To be precise, this example is a mix of product-oriented and result-oriented PSS typologies.

7 For deepening on the PSS benefits, see UNEP (2002), Mont (2002, 2004) and Tukker and Tischner (2006).

8 Several research projects have been funded by the EU in the last years on this topic; for instance, Product and Service Co-Design Process (PROSECCO), Highly Costumerized Solutions (HiCS) (Manzini et al., 2004) and Method for PSS Development (MEPSS) (van Halen et al., 2005).

9 For an analysis of sustainability per type of PSS, see Tukker and Tischer (2006, pp.92–95).

10 In relation to that, see Vezzoli and Ceschin (2008a, 2008b).

11 An example is LeNS, the Learning Network on Sustainability (2007–2010), EU funded research project under the Asia-Link Programme, is a project for curricula development and teaching diffusion on Design for Sustainability focused on PSS innovation (http://www.lens.polimi.it).

Fonte: International Journal of Automotive Technology and Management, v. 10, n. 2-3, p. 321 - 341, 2010. [Base de Dados]. Disponível em: http://www.inderscience.metapress.com. Acesso em: 26 maio 2010.