Product-Service System Design for Sustainability

Carlo Vezzoli, **Cindy Kohtala** and **Amrit Srinivasan**

with **JC Diehl, Sompit Moi Fusakul, Liu Xin** and **Deepta Sateesh**

LeNS

Learning Network on Sustainability

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United Nations Decade of Education for Sustainable Development (DESD). In December 2002, the United Nations General Assembly (UNGA) adopted resolution 57/254 to put in place a United Nations Decade of Education for Sustainable Development (DESD), spanning from 2005 to 2014, and designated UNESCO to lead the Decade. The United Nations Decade of Education for Sustainable Development seeks to integrate the principles, values, and practices of sustainable development into all aspects of education and learning, in order to address the social, economic, cultural and environmental problems we face in the 21st century. During this decade, education for sustainable development will contribute to preparing citizens better prepared to face the challenges of the present and the future, and decision-makers who will act responsibly to create a viable world.

ESD supports five fundamental types of learning to provide quality education and foster sustainable human development—learning to know, learning to be, learning to live together, learning to do and learning to transform oneself and society. (www.unesco.org/education/desd --- esddecade@unesco.org)

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Foreword

Arturo Dell'Acqua Bellavitis
Dean of the School of Design, Politecnico di Milano, Italy

Silvia Piardi
Head of the Design Department, Politecnico di Milano, Italy

During the last few decades, the history of design culture and practice, when dealing with the issue of sustainability, has moved from individual products to systems of consumption and production, and from strictly environmental problems to the complex blend of socio-ethical, environmental and economic issues.

In fact, design can take a proactive role and become a part of the solution, i.e. an agent for sustainability. It can do so because within its genetic code there is the idea that its role is to improve the quality of the world: an ethical-cultural component that, though not generally apparent, can be found in a deeper examination of the majority of designers' motivations.

At the same time, design can actually become an effective agent for sustainability because it is the social actor that above all others, by its very nature, has to deal with the everyday relationships of human beings with their artefacts and with the expectations of well-being that are built on them. That is, design has to deal with the core of the problem: the change towards sustainable ways of being.

A long journey is ahead of us. And from this perspective I believe this book will contribute to a larger change in the design community requested to meet this challenge.

Helena Hyvönen
Dean, School of Arts, Design and Architecture, Aalto University, Helsinki, Finland

with Cindy Kohtala
LeNS project team, Department of Design

and Tiina Laurila
Programme Director of Creative Sustainability Master's Programme

John Thackara once suggested that we are all emerging economies—rich countries, poor countries, in-between regions—that nowadays the very notions of 'progress' and 'development' too often clash with existing cultural practices and social capital. This is a useful, even necessary, perspective to adopt, as the global pace of change and scale of uncertainty continues to accelerate. No country or region can be assured of future status, job security, resource security, even food security; the globalised web that we have spun for ourselves entangles us into demand for mutual responsibility.

Our country of Finland, for instance, pulled herself up from the horrors of war and a struggling agrarian existence to become a highly educated nation whose 'design drivers' have been equality, cooperation, and a deep respect for nature. Even so, we face the same challenges as other countries in the North: job flight and adaptation to rapid global economic changes, a growing gap between rich and poor, and significant demographic shifts. If we are emerging into a post-industrial context, how do we define 'progress'? Or success? Or rather—how should we? And most importantly, who is it that decides on the definition we use?

These complex global and local challenges raise the role of higher education and research as an essential element of sustainable development in society, requiring the inter-linkage of environmental, economic, socio-cultural aspects also in education.

At Aalto University one concrete answer to this challenge was launching the international Master's Degree Programme in Creative Sustainability (CS) in autumn 2010, an interdisciplinary teaching platform in the fields of architecture, urban planning, landscape planning, real estate, business and design. The CS programme brings together students to study in multidisciplinary teams in order to enhance understanding of different disciplines and activate them to create new sustainable solutions for community, urban, industrial and business environments. In the near future, more organisations will take a strategic position on transformation towards sustainability; therefore an increasing number of professionals who are capable of a holistic approach to sustainability will be needed to work as multidisciplinary experts in these organisations. Among the competences required in future jobs, design thinking—those creative problem-solving capabilities that utilise design process methods to define the problem, generate ideas and implement solutions—is key.

For these reasons, we feel the publication of this book could not be more timely, as students, teachers and researchers in design schools must not only speak their own disciplinary language fluently, but must also be able to communicate with

other disciplines and experts in the design of sustainable systems. If we are all emerging economies, we recognise that we have lessons to learn and success stories to share. We all need to identify and dismantle the models that are unsustainable and rebuild them, while strengthening the models that are promising in their compliance with sustainability principles. This is a process that will redefine what we mean by 'development' for humanity on earth.

S.N. Singh

Dean, Industrial Research & Development (IRD), Indian Institute of Technology Delhi, India

It gives me great pleasure to contribute to the Foreword of *Product-Service System Design for Sustainability*, the innovative new textbook brought out by the recently concluded LeNS Project of the European Commission's Asia-Link Programme. LeNS was one of the few chosen projects awarded to the Indian Institute of Technology, Delhi by the EC. As Dean of IRD, The Industrial Research and Development Unit of the IIT Delhi which has looked after the project right from its inception in December 2007 I congratulate Professor Carlo Vezzoli, Politecnico di Milano, Italy (Co-coordinator) and Professor Amrit Srinivasan (Principal Investigator, IIT Delhi) for their futuristic vision in bringing out this much needed publication on sustainability in design pedagogy and research. The book very effectively reflects the spirit of academic exchange that took place during the tenure of the project among the partner institutions and countries of LeNS—Italy, the Netherlands, Finland, India, China and Thailand. Also, by making this textbook available as a free and downloadable version along with the printed text it is a mission well accomplished by LeNS.

I congratulate the editors and contributors for the path breaking progress they have made in the discipline of design education and in helping us achieve a sustainable society.

Zheng Shuyang

Dean of Academy of Arts & Design, Tsinghua University, Beijing, China

Humankind's continuation and the progress of civilisation are influenced by the development of design.

Design for Sustainability in essence is a macro strategic concept. The balance between 'environment and development' is not only the core of any national strategy on sustainable development, but also a basic sign of the balance between 'human and nature'. Therefore, Design for Sustainability becomes a key element in maintaining the balance.

The optimum state to reflect the ideal living environment of human beings includes a virtuous cycle of the ecosystem, civilisation and progress of the social

system, appropriate allocation of natural resources, and scientific construction of living space. The implementation system of the overall sustainable development strategy is then Design for Sustainability.

In the context of the global village, it is impossible to realise the dream of sustainability in ecological civilisation by only relying on one city, one region, or even one country. The hope lies in worldwide cooperation and international comprehensive coordination, which forms the global concept of Design for Sustainability.

Rapid economic growth, the huge and expanding population, massive consumption of natural resources, and unbalanced regional development put great pressure on the environment and the development of China in the 21st century. In parallel, these factors will also have a negative impact on the world. China is in the dilemma of neither following the 'pollution first, treatment later' way of the developed nations, nor avoiding placing priority on 'development'.

Confronted with the global challenges and opportunities brought by sustainable development, as professional designers and design educators of China, we are shouldering even greater responsibilities. How to solve the contradictions between 'environment and development' and how to find a proper balance point between the two will be an enormous undertaking for the future. Therefore, SPSS design has an important role in answering this challenge.

Sompit Moi Fusakul

Course Director, Master of Architecture Program in Industrial Design, Faculty of Architecture, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand

At the beginning of the LeNS project, we found the term 'Product-Service System' to be challenging, yet we are confident that our painstaking efforts will have worthy results: helping us find a better way to educate young designers suitable for this increasingly deteriorating world. The LeNS project offered the opportunity to delve into the essence of PSS and DfS in addition to the chance to share knowledge with all of our inspiring and supportive partners.

Complementary to the PSS approach, we have another main agenda: to explore how design could contribute to a 'Sufficiency Economy'—a unique philosophy bestowed by our beloved HM King Bhumibol Adulyadej. In exploring the connections between PSS and Sufficiency Economy approaches, we identified similarities and differences, and as we progressed, we realised that PSS is naturally embedded in Thai culture even though the term 'Product-Service System' is not common as such.

The progress of other researchers and thinkers on Sustainability paved the way to our interpretation of 'Design for Sufficiency Economy (DSEP)'. Within this book, readers will find not only practical information that help design educators develop a course on PSS, but also a brief report on how DSEP could help to achieve a more balanced lifestyle toward self-reliance; promote humanity's harmonious relationship with nature and society; and to modernise in line with the forces of

globalisation while preserving human dignity and cultural values. This exploration can be seen as a 'work in progress' since DSEP is still in its beginning phases. We are still exploring, with much to argue and conclude. Even after the LeNS project, research on DSEP must be continued because the world could better proceed towards sustainability by having sufficiency as a critical step.

If one observes people on a hot, sunny beach, most seek shelter under umbrellas. However, it is not the umbrella but rather its shadow that people seek. For us, the Sufficiency Economy and Sustainability create similar 'shadows'. Although both differ in their nature, they do have one similar function—to create a silhouette that would shelter people to live on with a more comfortable life. The expansion of these umbrellas should be encouraged, and by doing so the whole world will soon become a cooler place to live.

Han Brezet

Research Director of the Faculty of Industrial Design Engineering, Head of the Design for Sustainability Research Program, Delft University of Technology, the Netherlands

Over time design has taken a more and more progressive role in teaching sustainability issues as well as solving these challenges in practice. Starting from Eco-design in the 1990s with a focus on redesign of existing products from an environmental point of view, the design world went to a next stage by including social aspects resulting in Design for Sustainability approaches. Subsequently, these design approaches towards sustainability went beyond products and led to more radical approaches such as Sustainable Product-Services and Sustainable System Innovation.

Even though more profound approaches towards sustainability were developed, its origin and focus was still somehow narrow: to a large extent these approaches were developed in a Western context. From this perspective, the LeNS initiative is unique by bringing together academics, educators and students from Asia and Europe to explore, discuss and develop teaching materials for Design for Sustainability and Sustainable Product-Service Systems. Consequently it has resulted in a distinctive knowledge base in this field. In addition the LeNS project distinguishes itself from many other projects by sharing the jointly developed materials for free on the internet, and as such providing educators and students worldwide with knowledge, approaches and examples to make a leapfrog start in developing their own courses or projects. We think that young designers, characterised by their open minds, critical and reflective thinking, as well as their multidisciplinary skills can be key to change towards a sustainability society.

This book provides a jumpstart by presenting a comprehensive overview of the state of the art on design and sustainability, from Asia to Europe, from Eco-design to Sustainable System Innovation, from academic and educational approaches to cases in the field.

We hope it will inspire you!

Geetha Narayanan
Founder-Director, Srishti School of Art, Design & Technology, Bangalore, India

It is with a sense of deep concern and the courage to hope against hope that I write this Foreword to the LeNS publication *Product-Service System Design for Sustainability*, a compilation that comes as the culmination of three years of collaborative teaching and exchanges between cutting-edge design colleges and a successful international conference in Bangalore hosted by the Srishti School of Art Design & Technology in late September 2010.

Concern, because Mother Nature is urgently questioning Humanity, by means of unexpected 'disasters' on a scale as yet not encountered, about our present trajectory propelled almost helplessly by ingrained traditions, political and economic ideologies and gigantic infrastructures making use of state-of-the-art concepts in engineering and design that are perhaps no longer relevant.

Courage, because it takes faith and hope in the face of our rising anxieties to challenge and equip designers, engineers, social scientists, educationists and, most importantly, the younger generation to approach the needs of our times and the future with both intelligence and spirit to form a new philosophy of non-discriminatory resilience. The LeNS project and conference, and this end-record of an emergent multi-disciplinary thinking that prioritises the sustainability of the human race, its artefacts and aspirations, yield a valuable contribution.

It is clear that the processes and practices of product-service system design must question the very roots of its 'evolution' (if it can be called that) till now primarily dependent on exclusive Western paradigms. Radical shifts must be based on inclusive global paradigms so that future innovation allows for the understanding, conceptualisation, design and implementation of a sustainability that benefits the planet and its inhabitants as a 'whole' and not as 'fragments'.

We must understand now that Nature does not spare rich or poor but has a stern warning for Humanity to pursue processes of 'enactive design' that are collaborative and comprehensive, enabling development which meets the needs of human beings across the globe in ways that are compassionate, just and equitable.

This book offers some gleanings towards such an end.

Introduction: sustainability in design

Design and sustainability: an increasing role

Historically, the reaction of humankind to environmental degradation, especially since the second half of the last century, has moved from an end-of-pipe approach to actions increasingly aimed at prevention. Essentially this has meant that actions and research focused exclusively on the de-pollution of systems have shifted towards research and innovation efforts aimed to reduce the cause of pollution at source.

In other words, the changes have been from:

- Intervention after process-caused damages (e.g. clean up a polluted lake), to
- Intervention in processes (e.g. use clean technologies to avoid polluting the lake), to
- Intervention in products and services (e.g. design product and services that do not necessitate processes that could pollute a lake), to
- Intervention in consumption patterns (e.g. understand which consumption patterns do not (or less) require products with processes that could pollute that lake)

Due to the characteristics of this progress, it is evident that the role of design in this context has expanded over time. This increasing role is due to the fact that:

- The emphasis shifts from end-of-pipe controls and remedial actions to prevention
- The emphasis expands from isolated parts of the product life cycle (i.e. only production) to a holistic life cycle perspective

- The emphasis passes further into the socio-cultural dimension, into territory where the designer becomes a 'hinge' or link between the world of production and that of the user and the social/societal surroundings in which these processes take place
- The emphasis widens towards enabling users' alternative and more sustainable lifestyles

Within this framework the discipline of **Design for Sustainability** has emerged, which in its broadest and most inclusive meaning could be defined as: 'a design practice, education and research that, in one way or another, contributes to sustainable development'.[1]

Design for Sustainability has enlarged its scope and field of action over time, as observed by various authors (Karlsson and Luttrop 2006; Rocchi 2005; Vezzoli and Manzini 2008a; Ryan 2004; Charter and Tischner 2001). The focus has expanded from the *selection of resources with low environmental impact* to the *Life Cycle Design* or *Eco-design* of products, to *designing for eco-efficient Product-Service Systems* and to *designing for social equity and cohesion*.

All this should be understood as a process widening the boundaries of the *object* of design. In fact, this interpretation of Design for Sustainability (and its four approaches: 1. selection of resources with low environmental impact; 2. design of products with low environmental impact; 3. Product-Service System Design for eco-efficiency; 4. design for social equity and cohesion) does not necessarily represent a chronological evolution, nor does it define precise boundaries between one approach and another, as its status varies in various contexts. Nevertheless it may be useful for a schematic understanding of the increased and increasing contribution of design to sustainability, as will be illustrated in the following sections.

Selection of resources with low environmental impact

One basic level on which numerous theorists and academics have been working is the selection of material and energy resources with low environmental impact.

Here the first issue has been the identification and selection treatment of **toxic and harmful materials**. In addition to a traditional competence in actual design, this demands from the designer an extended knowledge about correlated norms and actual adoption of the rather general *precautionary principle*.

Another closely related topic that has an influence on other environmental problems is waste management, especially **recycling** and re-using materials and **incineration** in order to recover contained energy. Over time it has been understood that handling design-for-recycling-and-re-use demands a transition from estimating

1 Some authors adopt a more stringent definition of Design for Sustainability: e.g. Tischner (2010) argues that Design for Sustainability requires generating solutions that are equally beneficial to the society and communities around us (especially unprivileged and disadvantaged populations), to the natural environment, and to economic systems (globally but especially locally).

the recyclability of materials to the economic and technological feasibility of the whole all-encompassing process. Thus design for recycling and re-use and its indicators must cover every single stage: collection, transportation, disassembly and eventually cleaning, identification and production of secondary raw materials and identifying opportunities for re-application.

One ongoing debate is on the subject of **biodegradability**: an environmental quality that has raised many misinterpretations. It is important for materials to be re-integrable with ecosystems. Nevertheless for many products biodegradable materials may pose a problem in the sense of a premature expiration date; this in turn creates new production and distribution processes for both substituting and discarding reasons.

Last, but not least, is the subject of **renewable resources** (either energy or material ones) and research and development on various alternative sources such as solar, wind, water, hydrogen and biomass power and their integration into (power-consuming) product systems. This topic has also taken some time to be understood properly, when renewability was associated with both the speed of recovery of the resource and with the frequency of utilisation. More precisely, it is crucial to understand that a resource is renewable only when it is replenished by natural processes at a rate comparable to its rate of consumption by humans.

Product Life Cycle Design or Eco-design

Since the 1990s, attention has partially moved to the product level, i.e. to the design of products with low environmental impact, usually referred as *product Life Cycle Design*, *Eco-design* or *Design for the Environment* (Keoleian and Menerey 1993; Brezet and Hemel 1997; Manzini and Vezzoli 1998; Tischner *et al*. 2000; Hemel 2001; Heiskanen 2002; Ryan 2003; Sun *et al*. 2003; ISO 14062 2002; Nes and Cramer 2006). In those years, the environmental effects attributable to the production, use and disposal of a product and how to assess them became clearer. New methods of assessing the environmental impact of products (the input and output between the techno-sphere, the geo-sphere and the biosphere) were developed; from among them the most accepted is Life Cycle Assessment (LCA). In particular two main approaches were introduced.

First, the concept of *life cycle approach*—from designing a product to designing the product life cycle stages, i.e. all the activities needed to produce the materials and then the product, to distribute it, to use it and finally to dispose of it—are considered in a holistic approach.

Second, the *functional approach* was reconceptualised from an environmental point of view, i.e. to design and evaluate a product's environmental sustainability, beginning from its function rather than from the physical embodiment of the product itself. It has been understood that environmental assessment, and therefore also design, must have as its reference the function provided by a given product. The design must thus consider the product less than the 'service/result' procured by the product.

Design for eco-efficient Product-Service Systems

From the end of the 1990s, starting with a more stringent interpretation of sustainability that called for more radical changes in production and consumption models, attention has partially moved to *design for eco-efficient Product-Service Systems*, a wider dimension than that of the single product (Stahel 1997; Hockerts 1998; Goedkoop *et al.* 1999; Lindhqvist 2000; Cooper and Sian 2000; Brezet *et al.* 2001; Charter and Tischner 2001; Manzini and Vezzoli 2001; Bijma *et al.* 2001; Zaring 2001; Mont 2002; UNEP 2002; Scholl 2006). From among several converging definitions, the one given by the United Nations Environment Programme (UNEP 2002) states that a Product-Service System (PSS) is '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'.

In this context, it has therefore been argued (Vezzoli 2003a) that the design conceptualisation process needs to expand from a purely *functional approach* to a *satisfaction approach*, in order to emphasise and to be more coherent with the enlargement of the design scope from a single product to a wider system fulfilling a given demand related to needs and desires, i.e. satisfaction.

This approach is the epistemic core of this book and is extensively elaborated upon in the following chapters.

Design for social equity and cohesion

Finally, design research has opened discussion on the possible role of *design for social equity and cohesion* (Margolin 2002; Razeto 2002; Mance 2001; Manzini and Jégou 2003; Crul 2003; Guadagnucci and Gavelli 2004; Rocchi 2005; Penin 2006; Tischner and Verkuijl 2006; Vezzoli 2003a; Leong 2006; Maase and Dorst 2006; EMUDE 2006; Carniatto *et al.* 2006; Carniatto and Chiara 2006; Weidema 2005; Crul and Diehl 2006; dos Santos 2008). This potential role for design directly addresses various aspects of a 'just society with respect for fundamental rights and cultural diversity that creates equal opportunities and combats discrimination in all its forms' (EU 2006). Moreover, several writers and researchers urge a movement (and a key role for design) towards harmonising society such that it is not only just and fair, but that people are encouraged to be empathic, kind and compassionate for the benefit of others (Fusakul and Siridej 2010; Rifkin 2010).

We can indeed observe new, although sporadic, interest on the part of design research to move into this territory, to trace its boundaries and understand the possible implications. This is an extremely vast and complex issue, and its implications for design have thus far been little analysed. They are also problematic to face without falling into easy, hardly constructive moralism.

Some authors (Crul and Diehl 2006; dos Santos *et al.* 2009; Kandachar 2010) argue that in low-income contexts, more immediate technical support is needed to introduce design for product sustainability; i.e. a Design for the Base of the

Pyramid (BoP) approach is proposed. Regarding social impact, other authors (Weidema 2005) are investigating the option of extending product Life Cycle Assessment beyond environmental impact to social impact, which is in principle more closely linked to the product innovation level.

Other authors (Soumitri and Vezzoli 2002; Kandachar 2010) have argued that a promising approach would be that of Product-Service System design for social equity and cohesion, or more generally, system design for sustainability. Furthermore, some authors (Fusakul and Siridej 2010)[2] propose the integration of a Sufficiency Economy Philosophy in the design of the system of products/services that support livelihoods or business at technological, socio-cultural, organisational and infrastructural levels.

This issue of Product-Service System design for social equity and cohesion is extensively explored and discussed in the following chapters.

If we then examine the theoretical contributions made by design culture in the field of consumption, not all of them are necessarily recent.[3] We can recall Tomas Maldonado who appealed for a new 'design hope' (Maldonado 1970), bringing up the question of the social responsibility of designers at the beginning of the 1970s. Victor Papanek expressed a similar position, regarding the role of consumption: 'design can and must become a means for young people to take part in the transformation of society' (Papanek 1971). These contributions were disseminated before the concept of sustainable development was even introduced at the end of the 1980s.

Design for sustainability: the current status

To gauge the current status of Design for Sustainability as a whole, we may consider the four dimensions described above according to two dimensions: the level of disciplinary consolidation (derived from the results of design research) and, second, their level and dissemination in design education and practice.[4] The new research frontiers represent no or very low consolidation and dissemination, while we wish to steer the various dimensions of the discipline towards a high degree of consolidation and widespread dissemination in design education and practice.

In industrialised contexts, represented especially by European countries, the choice of low impact material/energy and the Life Cycle Design (LCD) or eco-design

2 See Part 2, Section 4.

3 Already at the end of the 1960s, for various reasons, the theory and culture of design in Italy anticipated a critique of consumption patterns, or at least some of the leading figures in the realm of design culture acted as spokespersons for issues relating to the responsibility of designers for consumption patterns, although in different ways and not directly and exclusively associated with environmental impact.

4 Note that the UN has declared the United Nations Decade of Education for Sustainable Development (2005–2014) with the scope of integrating the principles, values, and practices of sustainable development into every aspect of education and learning. This means that it should be an obligation for every design university to establish courses on Design for Sustainability.

of products are positioned at a good level of consolidation (Vezzoli and Manzini 2008a), with a modest level of penetration in design education and practice. For eco-efficient PSS design, the level of consolidation is inferior and education and practice is, logically, far more sporadic.

Very few design researchers are working on the design for social equity and cohesion front. It is in fact a new research frontier, meaning that little has been shared in the design community on a theoretical level and few methods and tools have been developed for the operative level.[5] In parallel there are very few curricular courses.

If we look at emerging countries and contexts, the landscape of Design for Sustainability research and education is more varied. Aguinaldo dos Santos (dos Santos 2008) has argued that in Brazil, for example, the socio-ethical dimension of sustainability has garnered attention earlier than product design for environmental sustainability. In Thailand, on the other hand, LCD/Eco-design teaching has a longer official history in the curriculum, but new courses have been implemented in higher learning institutes using methods and tools such as Design for a Sufficiency Economy and Design for Social Enterprise. These address prominent new social movements and discourse in Thailand regarding both social equity and social cohesion and the philosophy of a Sufficiency Economy. Design research in sustainability has thus been enhanced and expanded in a unique way, emphasising the design of appropriate ways of life that foster public consciousness or allow opportunities for users to do good through their consumption choices or activities.

Some authors have argued that the differences between Design for Sustainability research in industrialised contexts compared to emerging and low-income contexts is largely due to differences in local industry need and innovation climates. Especially in the least industrialised regions, whose economy and labour market are dominated by micro Small and Medium sized Enterprises (MSMEs), companies' product development processes are generally unstructured and based on practical experience as well as benchmarking what is already familiar. Staff tend to be less educated and operating sectors tend to be low-tech, such as food processing or metal processing. The drivers for Design for Sustainability practice and research therefore differ when comparing industrialised and low-income or emerging contexts. External drivers such as legislation and consumer and supplier demand that play the key role in the European context, for instance, are not present to the same extent in emerging contexts. The main driving forces for Design for Sustainability in less industrialised economies are seen more in internal drivers such as cost efficiency, competitiveness and new markets (Crul and Diehl 2008, 2006).

In this volume we will focus our attention on Product-Service System design for environmental, socio-ethical and economic sustainability, for industrialised, emerging and low-income contexts, with the aim of contributing to the diffusion of such an approach to design.

5 Cf. Part 1, Chapter 4.

The structure of this book

The scope of this book is to introduce and describe the theory and the practice of **Product-Service System Design for Sustainability**.

The book is divided into two parts:

Part 1 is a basic textbook on **Consolidated knowledge and know-how on Product-Service System Design for Sustainability**: designed primarily to meet the demands of a course taught at undergraduate level.

Part 2 is an advanced textbook on **The new design frontiers of Product-Service System Design for Sustainability**: designed primarily to meet the demands of a course taught at postgraduate (MSc, PhD etc.) level.

In particular **Part 1** of the book is organised as follows.

- The first chapter will describe the conceptual framework, the meaning and implications of sustainable development: namely, the need for system discontinuity
- The second chapter introduces the concept of PSS innovation and explains why it is a promising approach to sustainability: i.e. capable of potentially bringing radical reductions in resource consumption, leveraged by the economic interest of the provider/s and without minimising consumers' level of satisfaction. It explains its characteristics and features, how the different types of PSS can be classified, and the related benefits, drivers and barriers. Examples of sustainable PSS are described
- The third chapter will illustrate the role, approaches, skills and criteria involved in designing PSSs for Sustainability
- The fourth chapter will present a methodology and several related tools to design sustainable PSSs adopted and tested within the LeNS project

Part 2 of the book explores promising research directions and hypotheses on sustainable PSS design. It is composed of themed sections and their chapters on the promising research directions on sustainable PSS design:

- New ways to deliver satisfaction and manage the transition
- New perspectives on sustainable PSS in low-income and emerging contexts
- New ways to leverage social innovation for sustainability
- New ways to design for moderation
- New ways to educate

The reading of the book may be complemented by the use of educational learning resources (slideshows, video recorded lectures) and design tools available for free and in open source and copyleft format on the LeNS website (www.lens.polimi.it).

PART I

PRODUCT-SERVICE SYSTEM DESIGN FOR SUSTAINABILITY: CONSOLIDATED KNOWLEDGE AND KNOW-HOW

1

Sustainable development and system discontinuity

1.1 Sustainable development

During recent decades the concept of sustainable development has entered the scene of international politics. This term refers to systemic conditions where on a planetary and regional level both social and productive development takes place:

1. Within the limits of environmental resilience,[1] i.e. within its capacity to absorb the effects of human impact without causing any irreversible deterioration
2. Without compromising the ability of future generations to meet their own needs, i.e. maintain the means, or natural capital,[2] which will be passed on to future generations
3. On the grounds of equal redistribution of resources following the principle that everyone has the same rights to environmental space,[3] i.e. the same access to global natural resources

1 Resilience is the capacity of an ecosystem to overcome certain disturbances without losing irrevocably the conditions for its equilibrium. This concept, extended planet-wise, introduces the idea that the ecosphere used for human activities has limits on its resilience, that, when surpassed, give way to irreversible phenomena of deterioration.

2 Natural capital is the sum of non-renewable resources and the environmental capacity to reproduce the renewable ones. But it also refers to natural diversity, to the amount of living species on this planet.

3 Environmental space is the quantity of energy, territory and primary non-reproducible resources that can be exploited in a sustainable way. It indicates the amount of environment available for every person, nation or continent to live with, produce or consume without surpassing the environmental resilience level.

Let us see how this concept has emerged and spread over time.

The environmental issue, understood as the impact of the production-consumption system on ecological equilibrium, began to be raised in the second half of the 1960s, as a consequence of the accelerating and spreading industrialisation. The first scientific works handling these problems were published at the beginning of the 1970s. International studies and debates considered the deterioration and exhaustion of natural resources as an undesirable effect of industrial development. The natural limits of our planet became more apparent in the light of both uncontrollable technological and productive development as well as the increase of the world's population.

International debate about environmental issues intensified and spread further during the 1980s. The pressure from public opinion intensified, and institutions took their stand with a series of ecological norms and policies examining productive activities and based on the *Polluter Pays Principle*. The watchword of the United Nations Environment Programme, and other institutions, then became *cleaner production*, defined as 'the continual redesigning of industrial processes and products to prevent pollution and the generation of waste, and risk for mankind and the environment'.

In 1987 an important study was drafted by the *UN World Commission on Environment and Development* to provide indicators regarding the future of humanity. This report was called *Our Common Future* and was the first to define sustainable development as '*a development that meets the needs of the present without compromising the ability of future generations to meet their own needs*'.

During the 1990s environmental issues reached the phase of maturity. The *Caring for the Earth: A Strategy for Sustainable Livin*g publication for the World Conservation Union (IUCN) by the United Nations Environment Programme (UNEP) and World Wide Fund For Nature (WWF) had a competing definition of sustainable development: '*improving the quality of human life within the limits of capacity to protect the ecosystems*'. This accentuates the possibility to actually improve human life conditions while safeguarding the Earth's capacity to regenerate its resources.[4] These two definitions considered together thus describe sustainable development as a practice that delivers benefits to human beings and ecosystems at the same time.

Another historical event of those years was the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992. This and other initiatives have provided a persistent integration of the concept of sustainable development into the documents of all international organisations, as a model for reorientation of social and productive development. Since 1994 sustainable development and environmental sustainability have formed a fundamental benchmark in the *5th Environmental Action Programme* of the European Commission.

4 See www.gcmd.nasa.gov/records/GCMD_IUCN_CARING.html.

Onwards from the 2000s (following the Johannesburg Conference and ten years after Rio de Janeiro) the necessity of awareness and active engagement of all social participants involved in the production-consumption circuit is even more present and pronounced. Particularly significant was the setting up of UNEP's Sustainable Consumption Unit in May 2000 (see UNEP 2000). The initial assumption was that 'in spite of the progress made by the industrial world and enterprise during the last decade […] the extent to which consumption exceeds the Earth's capacity to supply resources and absorb waste and emissions is still dramatically evident' (Geyer-Allely 2002).

In June 2006 the European Council adopted an ambitious and comprehensive *Sustainable Development Strategy (SDS)* for an enlarged EU.[5] It builds on the Gothenburg strategy of 2001 and is the result of an extensive review process that began in 2004. The renewed EU SDS sets out a single, coherent strategy on how the EU will more effectively live up to its long-standing commitment to meet the challenges of sustainable development. It recognises the need to gradually change our current unsustainable consumption and production patterns and move towards a better integrated approach to policy-making. It reaffirms the need for global solidarity and recognises the importance of strengthening our work with partners outside the EU, including those rapidly developing countries that will have a significant impact on global sustainable development.

The European Council in December 2009 confirmed that 'sustainable development remains a fundamental objective of the European Union under the Lisbon Treaty'. As emphasised in the Presidency's 2009 review of the Union's Sustainable Development Strategy, the strategy will continue to provide a long-term vision and constitute the overarching policy framework for all Union policies and strategies. A number of unsustainable trends require urgent action (EU 2009).[6]

In parallel with this EU sustainable development strategy, Asian countries have equally been developing various locally relevant strategies to co-exist harmoniously with nature. Numerous royal projects in Thailand, for example, led by His Majesty King Bhumibol Adulyadej, emphasise the revitalisation of natural resources, conserving cultural heritage and prioritising human development and people's well-being according to the philosophy of a Sufficiency Economy. In May 2006, UN Secretary General Kofi Annan presented the first ever Human Development Lifetime Achievement Award to His Majesty the King in recognition of His Majesty's visionary thinking and sixty years of contributions to human development.

From a global perspective the UN approach has been to break down general policy frameworks into regional and country agendas. This has been the case with Agenda 21 (with the development of Local Agenda 21 in local levels of government) and it is the case for Sustainable Consumption and Production (SCP). The Marrakech Process, a joint initiative by UNEP and UN DESA (United Nations Department

5 EU, Renewed Sustainable development strategy, Council of the European Union. No. 10117/06, Brussels, 2006.

6 See www.ec.europa.eu/environment/eussd.

for Economic and Social Affairs), promotes and supports regional and national initiatives to promote the shift towards sustainable consumption and production (SCP) patterns. Among its actions is the organisation of National Roundtables and regional consultations in regions and countries, as well as the Task Forces, the main mechanism for implementing 'concrete projects and programmes at the regional, national and local levels to develop and/or improve SCP tools and methodologies'.

The result of the effort is a draft 10-year Framework of Programmes on SCP which will then be negotiated by countries at the 19th session of the UN Commission on Sustainable Development in 2011.

The UN's agenda is to recognise the diversity of countries and their economic and social systems, especially considering the disparity of environmental impact produced by industrialised, emerging and low-income countries/contexts and the pressing needs for social inclusion and its related basic needs. This has been an important parameter for sustainable development and the SCP approach throughout the UN's directives and policy orientation. The positive assertion is that the necessary shift towards sustainability is presented as an *opportunity* for emerging and low-income countries/contexts rather than yet another burden to be borne. For emerging economies, this entails leapfrogging to sustainable structures of consumption and production without repeating the mistakes of the West, and for low-income contexts, developing dedicated solutions as the basis for sustainable growth (Tukker, Stø and Vezzoli 2008a). While general guidelines are certainly important to help us understand our place in the big picture, it is when they reach the regional, national and local level and are incorporated and translated into local action that the real potentialities and difficulties can be measured.

At the educational level it is important to note that UNESCO has established a *Decade on Education for Sustainable Development* (UN DEDS 2005-2014).[7] The Decade aims to integrate the values inherent in sustainable development into all aspects of learning, to encourage changes in behaviour that will enable a more viable and fairer society for everyone. During this decade, education for sustainable development will contribute to citizens becoming better equipped to face the challenges of the present and the future and decision-makers acting more responsibly to create a viable world.

1.2 The sustainability dimensions

For a better understanding of sustainability and its implications, it is common to schematise it as three (interlinked) dimensions:

- The **environmental (Planet)** dimension: not to exceed the 'resilience' of the biosphere-geosphere, that is, its ability to absorb anthropic perturbations

7 See www.unesco.org/education/desd.

without provoking irreversible phenomena of degradation such as global warming, ozone layer depletion, acidification, eutrophication

- The **socio-ethical (People)** dimension: the ability of future generations to meet their own needs and the achievement of social equity and cohesion, where a key issue is equal redistribution of resources following the principle that everyone has the same access to global natural resources
- The **economic (Profit)** dimension: economically practicable solutions, in a more or less norm-oriented market

These dimensions have certain significant and characterising features that are described in the following paragraphs.

1.2.1 The environmental dimension (Planet)

In the 1960s, industrialised countries saw a strong acceleration in the development of consumption and production systems, but it was soon realised that this did not produce only advantages. In those years we can recall the pollution of the Great Lakes in North America; the winter smog in London at the end of the 1950s, which led to the death of thousands of people; and the ecological disasters caused by the washing of cargo tanks from oil tankers into the sea.

In 1972 the book *Limits to Growth* (Meadows *et al.* 2006) was published, the first computerised simulation of the effects of the ongoing system of production and consumption on nature; it was the first scientific forecast of a possible global ecosystem collapse. Hence these were the years of the discovery of environmental limits (and irreversible harmful effects). Still today we face such dangers. The smog from Suspended Particulate Matter (SPM) in cities affects thousands of victims each year; ozone layer depletion makes sunbathing increasingly dangerous; and global warming increases the violence of climatic phenomena, often with many victims.

If we examine the exact meaning of these environmental effects, we see that each environmental effect is based on an impact of exchanging substances between nature/the environment and the production and consumption system.[8]

These effects can occur in two directions:

- As *input*, namely extracting substances from the environment
- As *output*, namely emitting substances into the environment

Which effects, then, must be considered in relation to environmental requirements?

Regarding **input**—extracting resources—the first harmful effect is their exhaustion, the social and economic result of which is a lack of resources for future generations.

8 Obviously not all impacts are equally damaging, if they are damaging at all. The release of 1 kg of water into the environment differs greatly from releasing 1 kg of asbestos powder in high concentration.

Related to this is the issue of altering ecosystem balance. For example, deforestation due to the use of timber in construction (of various types of artefacts) or in heating systems has made the land more vulnerable to erosion over the course of time and caused the extinction of several species.

Finally, there are the harmful effects connected to extraction processes, e.g. oil leaks during extraction and transportation processes. These issues will be discussed further below together with outputs.

Regarding **output**—emitting resources—the main environmental impacts and the main environmental *effect*s of such *impacts* are listed in Table 1.1.

Table 1.1 **The main environmental impacts and their environmental effects**

Environmental impact	Environmental effects
global warming (greenhouse effect)	melting of polar ice-caps, rising seawater levels, inundated lowlands desertification migration of pathogens
ozone layer depletion	damage to flora and fauna elevated skin tumour risk immune system weakening
eutrophication	loss of aquatic fauna due to oxygen depletion contamination of groundwater and lakes, resulting in non-drinkable water obstacles to swimming
acidification	limited regrowth of forests limited regrowth of trees in urban zones corrosion of monuments and buildings contamination of groundwater loss of aquatic fauna sanitary risks (respiratory problems)
smog	some organic compounds (e.g. aldehydes) provoke lacrimation and irritate respiration some compounds (e.g. PAN) can have toxic effects on plants
toxic emissions	dioxin (TCDD) provokes chloracne and soft tissue cancer inhaling pyrene and benzopyrene is highly carcinogenic lead poisoning (saturnism) may cause irreversible neurological damage
waste	presence of waste: reduces availability of waste disposal sites pollutes soil and groundwater creates olfactory pollution and explosion hazard in landfills waste transportation implies: fuel consumption noise and air pollution
others	olfactory pollution acoustic pollution electromagnetic pollution deterioration of the landscape

Observing the relations between the anthropic world and nature altogether, we can distinguish two fundamental actions.

- Concerning the **input** from nature we must **preserve resources**, using fewer resources and preferably more renewable ones
- Concerning the **output** we must **prevent the pollution** (of resources), reducing emissions and increasing their biocompatibility

These actions can be further elaborated into three related scenarios.

First there is a **biocompatibility** scenario where the resource flows for the production of goods and services are compatible with the natural system: using renewable resources and disposing of biodegradable and biocompatible emissions and waste. In industrialised economies, this scenario has several limits that must be faced.

A second possible scenario is **non-interference** where resources are no longer drawn from nature but are rather recycled (if raw materials) or used in cascade (if energy resources).

This scenario also has its limits, at minimum, the laws of thermodynamics which always increase entropy during any process of transformation.

Finally we can imagine a third scenario of **dematerialising how we satisfy the demand for well-being (i.e. 'dematerialising demand for satisfaction')**, where resource flows would be quantitatively diminished in relation to a given social demand for needs and wants satisfaction.

It is therefore clear that the transition towards sustainable development will consist of a mix of these scenarios depending on the various conditions in different contexts.

1.2.2 The socio-ethical dimension (People)

Promoting socio-ethical sustainability means taking into account (according to the assumptions of the concept of sustainable development) the so-called *equity principle* (UN 1992), whereby every person, in a fair distribution of resources, has a right to the same *environmental space*, i.e. to the same availability of global natural resources or better, to the same level of satisfaction that can be had from these in different ways. When the issue of sustainable consumption crosses that of socio-ethical sustainability, the spectrum of implications, of responsibilities, extends to several different issues such as the principles and rules of democracy, human rights and freedom; the achievement of peace and security; the reduction of poverty and injustice; improved access to information, training and employment; and respect for cultural diversity, regional identity and natural biodiversity (UN 2002).

When talking about the socio-ethical dimension of sustainability a dominant issue is that of ***poverty eradication***.

In 2006 the World Bank and the United Nations Population Fund (UNFPA) reported the following dramatic poverty statistics:[9]

9 See www.heartsandminds.org/poverty/hungerfacts.htm

- 1.37 billion people live on less than 1.25 US dollars a day[10]
- 2.56 billion people (40% of the world population) live on less than 2 US dollars a day
- 1 billion children (1 in 2 children in the world) live in poverty
- 10 million children die every year before their fifth birthday
- 18 million people a year die (1/3 of all deaths) due to poverty
- 8 million people die from lack of food and nutrition
- 1.1 billion people have no access to safe water
- 2.6 billion people lack access to basic sanitation
- 800 million people go to bed hungry every day
- 640 million live without adequate shelter
- 270 million have no access to health services

In 1996 a summit organised by the UN's Food and Agriculture Organisation (FAO) was held in Rome, where 185 countries agreed and committed to cut the number of undernourished people by half. Four years later, on 8 September 2000, following a three-day Millennium Summit of world leaders at the UN headquarters, the General Assembly adopted the *Millennium Declaration*[11] signed by 191 member states. For example, the Declaration undertook to:

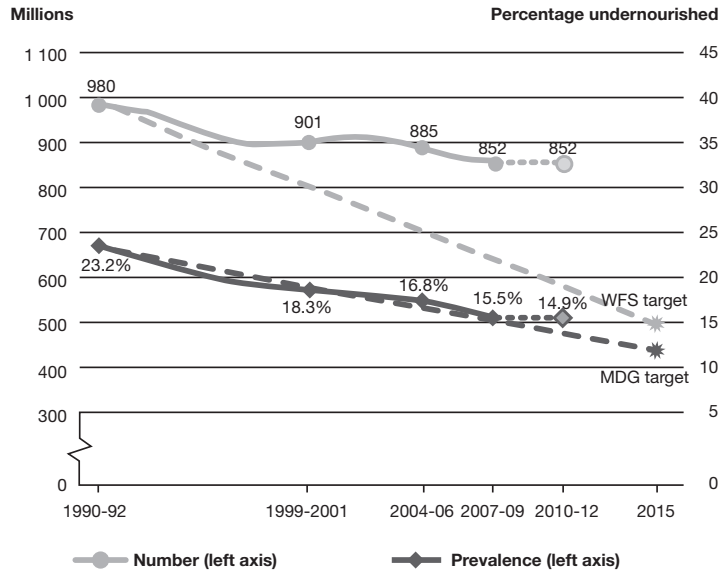
> eradicate poverty by 2015: a) reduce by half, from 1990 to 2015, the percentage of persons living in extreme poverty; b) grant a full and productive employment and a dignified job for all, including women and youngsters; c) reduce by half, from 1990 to 2015, the percentage of undernourished persons.

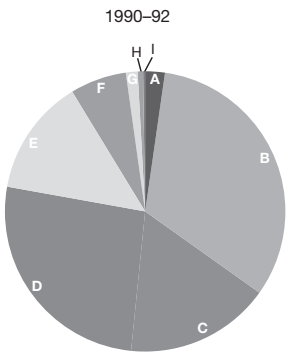
The *State of Food Insecurity in the World 2012* report by the FAO presents estimates of the number and proportion of undernourished people going back to 1990, defined in terms of the distribution of dietary energy supply.[12] With almost 870 million people chronically undernourished in 2010–12, the number of hungry people in the world remains unacceptably high. The vast majority live in low-income and emerging countries, where about 850 million people, or slightly fewer than 15 per cent of the population, are estimated to be undernourished. As shown in Figure 1.1 any notable progress was achieved before 2007–08. Since then, global progress in reducing hunger has slowed and levelled off.

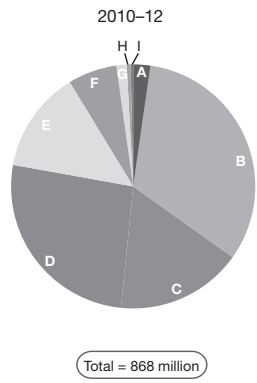
10 The World Bank defines extreme poverty as living on less than US$1 (PPP) per day, and moderate poverty as less than $2 a day.
11 See the full document at www.undemocracy.com/A-RES-55-2.pdf
12 www.fao.org/docrep/016/i3027e/i3027e.pdf

Figure 1.1 **Undernourishment in low-income and emerging regions**

Source: Food and Agriculture Organization of the United Nations, 2012, FAO, WFP and IFAD, *The State of Food Insecurity in the World 2012. Economic growth is necessary but not sufficient to accelerate reduction of hunger and malnutrition*, www.fao.org/docrep/016/i3027e/i3027e.pdf. Reproduced with permission.







Number of undernourished *(millions)*

	1990–92	2010–12
A Developed regions	20	16
B Southern Asia	327	304
C Sub-Saharan Africa	170	234
D Eastern Asia	262	167
E South-Eastern Asia	134	65
F Latin America and the Caribbean	65	49
G Western Asia and Northern Africa	13	25
H Caucasus and Central Asia	9	6
I Oceania	1	1

After all this, it is worth noting that social equity is not only a matter of eradicating poverty, but more widely a matter of facilitating an improvement in quality of life, by the 'promotion of a democratic, socially inclusive, cohesive, healthy, safe and just society with respect for fundamental rights and cultural diversity that creates equal opportunities and combats discrimination in all its forms' (EU 2006).

1.2.3 The economic dimension (Profit)

Regarding economic sustainability, the principle is that an environmentally and socio-ethically sustainable model of production and consumption should also be economically feasible. Three main strategies could be drawn regarding this dimension: internalisation of costs, orientating the main ongoing transitions towards sustainable solutions, and enhancing promising niche market economic models.

We can observe that in industrialised contexts many natural resources have low costs which do not correspond to the cost of their actual use. Removing wood from tropical forests may lead to erosion, loss in biodiversity and other negative effects that are not taken into account in the purchasing price but are a cost for society. Using petrol carries with it consequent CO_2 emissions that contribute to global warming. Furthermore, indirect costs appear when resources are embedded in products, generating life cycle environmental and economic costs. The producer and the user of a car pay very little of the indirect costs of the car, such as health costs incurred by society when people contract lung illnesses due to polluted air.

The **internalisation of costs** would entail embedding in the cost of the resource all direct and indirect costs, in order to encourage the minimisation of environmental impacts. In other words we should move towards a proper attribution (or internalisation) of resource costs, which is mainly a political and legislative issue.

Another strategy is to **orientate the main ongoing transitions** towards sustainable solutions, i.e. transitions regarding interconnection, globalisation and localisation (referred together as *glocalisation*), information, services, etc. (A simple example to illustrate this would be exploiting the dematerialisation potential of new ICT and e-mail systems if compared to the traditional postal system.) In fact, re-orientating may produce much more effective results, than, say, attempting to go back in time and return to former production-consumption models.

Finally, and complementary to the above strategy, it could be very interesting to promote and **enhance promising economic models** even if they are currently with **niche market value**.

Some promising models fitting into the frame of environmental and socio-ethical sustainability have been studied, such as Distributed Economies (DE) and Product-Service Systems (PSS), the latter forming the core of this volume.

1.3 Sustainability: demand for radical change

1.3.1 The size of the change

During the second half of the 1990s a series of studies and analyses led to a clearer understanding of the dimension of change necessary to achieve a society that is effectively and globally sustainable. It was then realised that conditions for sustainability can only be achieved by drastically reducing the consumption of environmental resources compared to the average consumption by mature industrialised societies.

Several studies—taking into account demographic growth forecasts and hypothesising an increase in the demand for well-being in currently disadvantaged countries and contexts—have staggering findings: in 50 years, conditions for sustainability are achievable only by increasing the eco-efficiency of the production-consumption system by a factor of ten. In other words we can only consider sustainable those socio-technical systems whose use of environmental resources per unit of satisfaction/service rendered is at least 90% below what is currently to be seen in mature industrial societies.[13]

Most study authors agree that if in the 1970s the goal was to slow down before hitting the limits, the goal must now be to get back down below the limits without war and severe damage to the earth. For example, if the current trends of overfishing and pollution continue, all seafood faces collapse by 2048. By the middle of the 21st century 7 billion people in 60 countries may be faced with water scarcity. Scientists have shown that human beings and the natural world are on a collision course (e.g. Meadows *et al.* 2006) and global society will most likely adjust to limits by overshoot and collapse, not by asymptotic growth.

1.3.2 The quality of change

These estimates (while currently under scientific discussion) are valid enough to indicate the scale of the change that should take place. A profound, radical transformation in our development model is necessary, and the production and consumption system in this sustainable society will be profoundly different from what we have been taking for granted up to now. In other words the transition towards sustainability requires **radical changes** in the way we produce, consume and, more in general, in the way we live. The prospect of sustainability necessarily places the model of development under discussion.

Over the next few decades we must enable ourselves to move from a society where well-being and economic health are measured in terms of growth in production and material consumption, to a context where economic growth cannot be seen as the ultimate goal and where, as Sen upholds (Sen 1999), freedom is the initial means by which to achieve a development that must be orientated towards improving life: freedom as a guarantee that people are the protagonists of their own destiny and not the passive beneficiaries of a development programme.

How this may happen is at present difficult to foresee. It is, however, certain that there will have to be a *discontinuity* that will affect all facets of the system. In other words, given the nature and the dimension of this change, we have to see

13 On this issue see works by the Wuppertal Institut fur Klima, Umwelt, Energy; by the Advisory Council for Research on Nature and Environment (in particular: The Ecocapacity as a challenge to technological development, a study funded by a group of Dutch ministries); by the Working group on eco-efficiency sponsored by the World Business Council for Sustainable Development (see particularly the final report Eco-efficient Leadership [WBCSD 1996]).

transition towards sustainability (and, in particular, towards sustainable ways of living) as a wide-reaching social learning process in which a *system discontinuity* is needed. In fact, the debate on more sustainable consumption patterns has been included in the agenda of major international governmental institutions in recent years (the United Nations, for instance, set up the *Sustainable Consumption Unit* in May 2000).

This complex debate can be summarised in the following question: how can we foster new quality criteria so as to separate the social demand for well-being from a relationship that is directly proportional to the increase in consumption of resources, characteristic of mature industrialised societies?

1.3.3 System innovations for a sustainable development

Keeping in mind that there are great differences between contexts, it has been argued above that if we are to take the concept of a sustainable society seriously, we need a *wide-reaching social learning process* in which a *system discontinuity* is catalysed. Therefore, when taking this to the implementation level, a **systems innovation** approach has emerged with the aim of seriously tackling the transition towards sustainability.

System innovations tend to imply changes at the level of components, the level of the architecture of technologies (Henderson and Clark 1990), and equally at the level of social and institutional arrangements, such as mechanisms of coordination (regulation, governance) or patterns of interaction at the supplier and the user side of innovation. At a system innovation level not only products, services and production systems are optimised and new ways of satisfying consumption needs are found within existing institutional frameworks and infrastructures, but new infrastructures, spatial planning and incentive systems are developed and implemented that promote more sustainable lifestyles (Tukker and Tischner 2006).

System innovations refer to major shifts in dominant 'socio-technical regimes'[14] and the way in which societal functions are fulfilled. They are long-term and complex processes between the social, economic, technological and policy domains (Rip and Kemp 1998; Geels 2002, 2004).

Within the wide debate on how to approach and foster system innovation (see e.g. Andersen 2006), the offer model of Product-Service Systems (PSS) appears a promising one to decouple resource consumption from value creation. This type of innovation is described in the following chapter. Nevertheless before doing this it is important to situate it within the context in which we are living today.

14 The socio-technical regime can be defined as the dominant way of innovating, producing, distributing, consuming etc. It is made up of different socio-economic stakeholders, practices, shared rules and ways of doing related to a specific field (mobility, energy, etc.).

1.4 Sustainability within a context in strong evolution

Nowadays it is very clear that contemporary social reality is no longer conceivable in terms of isolated, rooted and independent worlds, nations or communities, since it is characterised by:

- The advent of information and communication technologies (technologies of knowledge that are at the base of productivity, competition and power)
- Interconnection (people, ideas, images, goods, and money that are circulating at an unprecedented scale)
- Networked societies (no longer divided into only independent and isolated nations or communities)
- Enterprises in networks (teamwork, networking, outsourcing, subcontracting, delocalisation, etc.)

In this age, individuals and ideas are more mobile than ever before in history: we live in a global context that is becoming more and more *interconnected* and *multicultural*. Individuals and groups seek to include the global in their (modern) activities, thus creating a new, modern subjectivity, as Appadurai claims, fundamentally characterised by the effect that the interconnected elements of mass electronic communications and mass migration have on the workings of our collective, social imagination (Appadurai 1996). It is an age in which the crisis of the nation state is evident, in which it cannot be taken for granted that effective public spheres are typically, exclusively or necessarily national; in which it seems hardly probable that nation states, in a complex interactive system, can in the long term govern relations between the global and the modern (Appadurai 1996). To use Bauman's evocative metaphor it is a *liquid modernity*, where more and more is transitory, modifiable and experimentable (Bauman 2000).

Although individuals continue to act in specific places, what has now become apparent is how various geographical areas are linked together in different ways by a continual circulation of objects, people and information. This has changed and will continue to change relationship patterns, concepts and our perceptions of near/far, pertinent/afferent, possible/impossible, belonging/extraneous, exclusive/inclusive, etc. We have thus entered a truly multicultural, interdependent world, which can be understood and changed only in a plural perspective that is able to converge cultural identity, global networking and multidimensional policy.

The new industrialised economy is organised, according to Castells (1996), on global networks of capital, management and information, whose access to technological knowhow lies at the root of productivity and competition. Despite the obvious technical problems we face daily and differences from context to context, interactive computer systems operate in wide-ranging, open networks, and the information technology paradigm has jumped from mere connection between computers to *co-operative computing*, which reaches beyond the position of the subjects involved in the interaction.

Out of networking as a fundamental form of competition in the new global economy (and its accompanying new information technology) a new organisation model has emerged: the *networked enterprise* (Castells 1996). These are enterprises (and a growing number of organisations and institutions) that are organised in networks of variable geometry, the webs of which make the traditional distinction between large and small companies less important. Networked enterprises provide services through their connectivity (their structural capacity to facilitate communication without interference between their component parts) and consistency (the degree of interest sharing between the goals of the network and those of its components). This is a new division of work based on the attributes and capabilities of each worker, rather than on the organisation of their working roles. Work is increasingly based on teamwork, networking, outsourcing and subcontracting.

Continuing along Castells's line of thought (1996), our contemporary societies are increasingly built around a bipolar opposition between the network (globalisation) and the ego (identity). The networked society looks increasingly like a *meta-social* mess to the eyes of most people, where setting up a meta-network leads to the disconnection of non-essential functions, of subordinate social groups and of devalued geographical areas.

Interconnection and multiculture are key context factors that some people very explicitly interpret as aggravating circumstances (to defend oneself against), others as a necessary field of confrontation (the starting point), and still others as an opportunity and driving force for sustainable innovation (to be exploited).

Finally, we also recognise that services, not products, comprise 50% of Europe's GDP (70% in Germany), 76% of US GDP, and in Asia, 40% in China, 69% in Japan, and 45% in Thailand. We must also acknowledge that (at the time of writing) we are in the context of a structural economic crisis, and even a social crisis, that began with the financial collapse of 2008. We are therefore facing a double crisis today, socio-economic and environmental, where many rightly talk about risks and how to prevent them. But at the same time we should talk about opportunities. And it is within the nature of design to consider *the opportunities and how to develop and promote them*.

1.5 The diverse paths towards sustainability

1.5.1 Industrialised, emerging and low-income contexts

Sustainability is a challenge for industrialised, emerging as well as low-income contexts.[15] However, achieving this goal in the different types of context requires

15 The following terminology is used: low-income is preferred over developing, and industrialised is preferred over developed, since they reflect more objective characteristics and less of a value judgement. Moreover it should be emphasised that the production and consumption model of industrialised contexts is far from being developed, in that it is the one creating most of the damaging environmental impacts. Contexts is preferred to countries because in different countries different socio-economic contexts may be present.

differing paths (Hart and Milstein 1999): while in *industrially mature contexts* there is the need to reduce the use of resources per 'unit of satisfaction' (together with improvement of quality of life), in *emerging contexts* the aim is to see how communities can orient towards sustainable consumption and production systems. In *low-income contexts* the impellent need is to enable the systems of production and consumption to cover basic needs and provide a subsequent basis for a sustainable growth.

It is the level of human satisfaction in relation to the earth's carrying capacity that has to be taken into consideration when measuring the sustainability level of a given context. The *Happy Planet Index*[16], for example, combines environmental impact with human well-being to measure the environmental efficiency with which, country by country, people live long and happy lives; it illustrates that the best scoring countries are not the highly industrialised ones but rather emerging countries in Central America. Moreover, knowing that today 80% of the world's population uses only 20% of resources and 20% of humans consume the other 80%, *social equity and cohesion* must be addressed. Thus even though satisfaction is not necessarily linked to resource consumption, it is obvious that a redistribution of resources has to take place. Moreover, it is important to underline that sustainability is not only a matter of resource redistribution, but it is connected, as previously stated, to a wider spectrum of socio-ethical implications and responsibilities.

In the following sections, we present an overview of paths to sustainability as delineated in European and Asian agendas.

1.5.2 European sustainability agenda

European countries in the EU today follow the norms, practices and policies established by the European Commission (EC) for what regards sustainable development. Sustainable development as such is addressed as a cross-cutting issue reflected in the policy orientation of many sectors, informing private and national public practices, applying the EC's indications at the local level.

For that reason, the three European countries involved in the LeNS project, Italy, Finland and the Netherlands, are to some extent very similar regarding the general approach to the sustainable development agenda. Naturally, local agendas are built and applied according to the specificities of each country's consumption and production systems.

The **Renewed EU Sustainable Development Strategy** adopted by the European Council since June 2006 establishes four key objectives:

16 The Happy Planet Index in fact shows that no country successfully achieves the three goals of high life satisfaction, high life expectancy and one-planet living (www.happyplanetindex.org).

Environmental protection

Safeguard the earth's capacity to support life in all its diversity, respect the limits of the planet's natural resources and ensure a high level of protection and improvement of the quality of the environment. Prevent and reduce environmental pollution and promote sustainable consumption and production to break the link between economic growth and environmental degradation.

Social equity and cohesion

Promote a democratic, socially inclusive, cohesive, healthy, safe and just society with respect for fundamental rights and cultural diversity that creates equal opportunities and combats discrimination in all its forms.

Economic prosperity

Promote a prosperous, innovative, knowledge-rich, competitive and eco-efficient economy which provides high living standards and full and high-quality employment throughout the European Union.

Meeting our international responsibilities

Encourage the establishment and defend the stability of democratic institutions across the world, based on peace, security and freedom. Actively promote sustainable development worldwide and ensure that the European Union's internal and external policies are consistent with global sustainable development and its international commitments.

We observe that the main concerns are to a great extent related to the well-being and welfare of EU inhabitants. Issues regarding the greening of the production sector are no longer the main focus of sustainability-related policies as was the case in past decades. This is related to the fact that Western Europe finds itself in a post-industrial phase, moving from a manufacturing-based economy towards a service-based economy. It is not by chance that in one of the key challenges listed above, *Sustainable consumption and production*, the word *consumption* comes before *production*. This significant approach is addressed by the SCORE EC project[17] as follows: 'Consumption has to be understood as an activity that takes part in and is partially driven by a system context, and not only aims to fulfil material needs, but

17 SCORE! Sustainable Consumption Research Exchange is supported by the EU`s 6th Framework Programme. It is a network project that acts as one of the EU's central support structures for the UN's 10 Year Framework of Programmes for Sustainable Consumption and Production (SCP).

also relates to symbolic and cultural values'.[18] Moreover, in the current globalised economy, the EC plays a decisive role in establishing regulations regarding industrial production and agriculture that will reflect in the dynamics of global trade, affecting thus the worldwide economy.

In the European Sustainable Consumption and Production Policies two issues can be highlighted. One is the decoupling of economic growth from environmental degradation as an overall strategy for SCP, leading us towards new patterns of well-being and socio-economic and even institutional structures. The second issue is the understanding that to achieve SCP, we must change 'the way we **design**, produce, use and dispose of the products and services we own and consume'.

In this sense, not only specific product-related policies have to be implemented (through for example EU eco-design policies and IPP, Integrated Product Policy), but a **systemic approach** is called into action, as adopted in the SCORE project:

> sustainable consumption and production structures can only be realised if experts that understand business development, (sustainable) solution design, consumer behaviour and effectiveness of (policy) instruments work together in shaping them. Furthermore, this should be linked with experiences of actors (industry, consumer groups, eco-labelling organisations) in real-life consumption areas.

The EU has been increasing its role as promoter of research and innovation aiming at economic competitiveness in a knowledge-based society, but it has also been an important force for the advancement of sustainable development knowledge, methods and application tools in a vast range of areas on a worldwide scale. The EU has been investing significantly in pro-sustainability research.

The EC through the Community Research & Development Information Service (CORDIS) establishes a new Framework Programme for research and technology development every five years, a financial tool to support research and development activities covering almost all scientific disciplines. Both the CORDIS Framework Programmes and other external cooperation programmes (for example EuropeAid) have been important mechanisms in the promotion of sustainability knowledge internally and externally to European borders. The EU has thereby been a key force in shaping sustainable development and SCP approaches in the world and, through initiatives such as the SCORE! Network, has been strengthening synergies with the UN in this regard.

18 This is also mentioned in the EU Sustainable Development strategy of 2006. SCP covers 'almost the full "human" (social) system and the (economic) support sub-system' (Tukker, Charter, *et al.* 2008b), thus dealing with environmental, social and as well as economic aspects.

1.5.3 Asian sustainability agenda

The rapid economic development in Asia has led to an increase in terms of access to goods and services (at least for some share of the population), but on the other hand it has created increased environmental pressure, including pressure on urban infrastructure and its consequent level of liveability, and social gaps especially the urban/rural gap. There is also great concern about the impact of this economic growth on the global environment in the long run:

> As China and India become world-class economies, they are set to join already industrialised nations as major consumers of resources and polluters of local and global ecosystems. And while the largest burden of these developments will fall on China and India themselves, the global impact is clear (Flavin and Gardner 2006).

It must be said that although escalating, the environmental impact per capita in China, for example, is still much lower than that of industrialised countries, and consequently, the ecological footprint per capita of a country such as China is far lower than that of European countries or the United States. India has been able to achieve this through traditional cultural consumption patterns relating in particular to food consumption and waste recycling.

Even with massive rural–urban migration, countries like India and China are still predominantly rural. On the local level, rural-based traditional lifestyles are being replaced by a western-like, product-based well-being mind-set, based on a resource-intensive economy and individualistic values. This, however, does not necessarily translate into actual well-being of the majority of the population.

Nevertheless it is in the cities that it is easier to perceive the impact of socio-environmental pressure deriving from accelerated economic growth, since cities are the arena where the transformation processes are more dynamic. According to the Worldwatch Institute (2006), from the twenty most polluted cities in world, sixteen are in China. By the year 2015, the six biggest cities in the world, with populations above 20 million, will be found in the emerging countries and more than half of them in Asia. Issues such as air pollution, mobility systems or food and water supply gain, in the urban arena, an unprecedented scale.

At the policy level, if the UN has been stimulating governments worldwide in the promotion of local SCP debates, national governments in their turn have also been responding to the pressing issues related to environment degradation. Unlike the three European countries involved in the LeNS project, which share much of the same sustainable development agenda, the three Asian LeNS project countries, Thailand, China and India, see greater variability in their priorities and policies. In China, for example, the new five-year economic plan (as of time of writing) stresses the need for the conservation of natural resources. Also in China, a Green GDP index has been created as an indicator for economic growth that also takes into consideration the costs of environmental impact and resource consumption.

According to recent research conducted by the IUAV and Camerino universities in Italy,[19] Chinese environmental policy from the early 1980s to date has been following the route of end-of-pipe solutions to cleaner production, towards a life cycle approach. However, models such as PSS that are linked to environmental issues, life quality improvements as well as new types of entrepreneurship have not yet reached policy level, and it is now beginning to emerge as a scientific area to be explored.

Sustainability is a critical issue in Thailand, which has a unique agenda: the Sufficiency Economy Philosophy (SEP), bestowed by the nation's King. The Sufficiency Economy Philosophy prioritises human development and placing people's well-being at the centre of development. SEP thus serves as a guide for people at all levels of society on how to live and behave toward the middle path. Implementers (ranging from farmers, businesspersons, politicians, government officers to educators) are thus enabled to meet global challenges, as the SEP intends to indicate the routes to recovery that lead to a more resilient and sustainable economy. It is a universal approach applicable and scalable to conducts starting from the level of families, communities, as well as the level of nation in development and administration so as to modernise in line with the forces of globalisation. It entails three components (reasonableness, moderation and self-immunity) and two conditions (knowledge and morality).[20]

19 Study conducted by Medardo Chiapponi and Laura Badalucco (IUAV University Venice, Dadi department) and Lucia Pietroni (Camerino University ProCAm Department) within the research project 'Il Made in Italy per la Cina' (Made in Italy for China). Internal document 'La sostenibilità ambientale in Cina, inquadramento generale e prospettive' (Environmental sustainability in China, general framework and perspectives), IUAV University, October 2006.

20 The Sufficiency Economy Philosophy is described in detail in Part 2, Section 4.

2

PSS innovation and sustainability

A more strategic and systematic approach to Product-Service Systems first emerged in industrialised contexts (mainly Europe), as mentioned in Chapter 1, as a business opportunity to decouple value creation from an increase in resource consumption and more generally detrimental environmental impact. In terms of origin (Baines *et al.* 2007), most authors since 1999 have been from Scandinavia (particularly from Sweden), the Netherlands or Italy. A few articles on PSS have emerged from Asia, although numerous relevant cases are presented without adopting the term 'PSS' per se.

In this chapter we will first see what a Product-Service System is, why a PSS is understood as an opportunity for system eco-efficiency in industrialised contexts, and finally why and how such an approach could be promising in emerging and low-income contexts, i.e. for all sustainability dimensions, environmental, socio-ethical and economic.

2.1 Product-Service System eco-efficiency

2.1.1 What is a Product-Service System?

As stated in the introduction, in recent years several design research centres, starting with a more stringent interpretation of environmental sustainability (requiring a systemic discontinuity in production and consumption patterns) have reset part of the debate on Design for Sustainability starting from a system innovation approach. In fact, several authors have observed that product Life Cycle Design or Eco-design implementation meets obstacles in traditional supply models of product sale (Stahel 2001; Cooper and Sian 2000; Lindhqvist 2000; Goedkoop *et al.*1999; Manzini and Vezzoli 1998).

For these researchers a more significant scope in which to act to promote radical changes for sustainable consumption seems to lie in widening the possibilities for innovation beyond the product: commonly referred to in this context as Product-Service Systems (PSS).

Table 2.1 lists some of the definitions provided during this period.

Table 2.1 **Definitions of Product-Service System**

Authors	Year	Definition
Goedkoop, van Halen, te Riele, Rommens	1999	A Product-Service System (or combination of products and services) is a set of marketable products and services jointly capable of fulfilling a need for a client. [...] The PSS may lead to a benefit for the environment in connection with the creation of a (new) business.
Mont	2002	PSS is a system of products, services, networks of actors and supporting infrastructure that continuously seeks to be competitive, satisfy customer needs and have a lower impact than traditional business models.
UNEP: Manzini, Vezzoli	2002	Result of an innovative strategy that shifts the centre of the business design and sale of products only (physical) to systems offering products and services that are jointly capable of satisfying a given application
Brandstotter	2003	PSS is a product of material and intangible services designed and combined so that both jointly are able to satisfy a specific need of a user. In addition a PSS may reach sustainability targets.
EU, MEPPS: Van Halen *et al.*	2005	Result of an innovation strategy focused on the design and sale of a system of products and services that are jointly capable of fulfilling a specific customer demand
Baines *et al.*	2007	PSS is an integrated offering of a product and a service that provides a value. Using a PSS offers the opportunity to decouple economic success from material consumption and thus reduce the environmental impact of economic activity.
UNEP: Tischner, Vezzoli	2009	System of products and services (and infrastructure), to jointly cope with the needs and demands of customers in a more efficient way with better value for both businesses and customers, compared to only offering products [...]. PSS can decouple the creation of value from the consumption of materials and energy and thus significantly reduce the environmental impact in the life cycle of traditional product systems.

To clarify this concept we can take the following example (UNEP 2002): given the 'satisfaction' in having clean clothes, we do not need only a washing machine, but also detergent, water and electricity (and the services that supply them), and maintenance, repair and disposal services. When we talk, then, about PSS innovation, it refers to an innovation that involves all the different socio-economic stakeholders in this satisfaction system: the washing machine and detergent producers,

the water and electricity suppliers, the user and those responsible for maintenance and disposal.

Furthermore, as we saw previously, it is a shared opinion that ideally PSS innovation 'continuously strives to be competitive, satisfy customer needs and have a lower impact than traditional business models' (Mont 2002), 'as a consequence of innovative stakeholder interactions and related converging economic interests' (UNEP 2002). Thus eco-efficient PSS innovation derives from a new convergence of interest between the different stakeholders: innovation not only at a product (or semi-finished) level, but above all as new forms of interaction/partnership between different stakeholders, belonging to a particular value production system (Porter and Kramer 2006).

In other words, the research interest in this innovation model relies on the fact that it can raise system eco-efficiency through innovative stakeholders' interactions.

The definition of an **eco-efficient PSS** proposed by the LeNS project runs as follows:

> **an offer model providing an integrated mix of products and services that are together able to fulfil a particular customer demand (to deliver a 'unit of satisfaction') based on innovative interactions between the stakeholders of the value production system (satisfaction system), where the economic and competitive interest of the providers continuously seeks environmentally beneficial new solutions.**

The main characteristics of eco-efficient PSS innovations are:

- They are rooted in a satisfaction-based economic model, i.e. each offer is developed/designed and delivered in relation to a particular customer *satisfaction*
- They are stakeholder interaction-based innovation, i.e. radical innovations, less so technological ones, as new interactions and partnerships between the stakeholders of a particular satisfaction production chain
- They have intrinsic eco-efficiency system potential, i.e. innovation in which it is the company/companies' economic and competitive interest that leads to an environmental impact reduction, where the creation of value is decoupled from resource consumption

In reality, this interpretation of *PSS innovation* forms part of the foundation and criteria already expressed in *product Life Cycle Design*. However, when this approach was adopted, it emerged even more clearly (as its basic assumption) that it was the reconfiguration of the system that constituted the starting point towards achieving certain results.

2.1.2 The limits of a traditional product sales/design approach

To understand in general terms why PSS innovation and related innovative stakeholder interaction could be more eco-efficient compared to traditional product

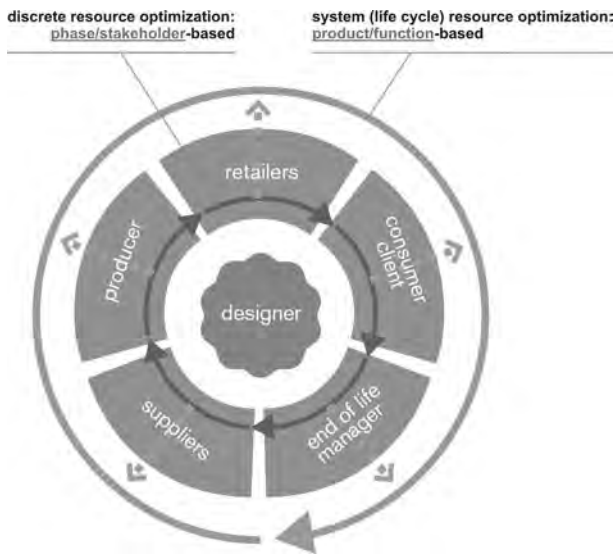
sales/design let us use the laundry example of *satisfaction* system again. For this satisfaction I do not need only a washing machine, but also detergent, water and electricity (and the services that supply it), and maintenance, repair and disposal services.

In the case of a traditional product sale/design, the producer of the washing machine (but also of the detergent and the electricity and water supply) has an interest in reducing material and energy consumption during the production phase. At the same time, she/he has no direct economic interest in limiting consumption during use, nor in reducing disposal impact or valorising the resulting waste. Sometimes the producer is even interested in selling products with a short life span, with the aim of accelerating replacement.

Similar arguments could be made regarding other (all) stakeholders of a particular product life cycle (stakeholders of the pre-production, the production, the distribution, the use and the end-of-life), so in a nutshell the economic interests behind traditional product sale or design lead the various stakeholders towards reduction of resource consumption of those processes under their direct control: i.e. an economic interest leads towards *discrete resource optimisation* (Figure 2.1). In other words, the biggest problems in the transformation processes do not appear within one given phase, when related to a single stakeholder (e.g. the manufacturer of a washing machine). In terms of eco-efficiency, more problems arise during the sale or disposal of (semi-finished) products. Here can arise *indifference towards reducing resource consumption* or even worse, an *interest to increase consumption of resources*. For example a producer of plastic has an interest to increase the sales of its materials (causing an increase in resource consumption).

Figure 2.1 **Stakeholders in a product life cycle: discrete vs. system resource optimisation**

Source: derived from UNEP 2002



In summary, applying a product Life Cycle Design approach in a traditional sale/design model (due to its sole focus on the sale of products) faces several constraints due to the low level of interaction among the *satisfaction system's stakeholders*.

Finally, we can observe that the fragmentation of stakeholders in the various phases of a product's life cycle (in the traditional economic framework of industrialised countries) means that the eco-efficiency of the life cycle system usually does not coincide with the economic interests of the individual constituent stakeholders.

2.1.3 PSS towards system eco-efficiency

From an eco-efficiency perspective, regarding the convergence between economic/competitive and environmental interests, it is useful to list all the innovative interactions and relationships between the stakeholders that, for economic reasons, could result in **resource optimisation based on product function**.

It is even more fruitful to map out those innovative interactions and relationships in the whole system of products and services that fulfil a particular demand, deliver satisfaction, and that could effectuate **system-satisfaction based resource optimisation**. In our example (Figure 2.2) these include the washing machine and detergent producers, the water and electricity suppliers, those responsible for maintenance, the user and the end-of-life manager.

In the light of the arguments arisen thus far, what are the incentives for companies to enhance system eco-efficiency? Are there economic models where the economic and competitive benefits for a company correspond to a reduction in resource consumption or more in general to a reduction in the environmental impact?

Let us look for innovative elements in the stakeholder interactions and configuration *innovations*.

Both **stakeholder integration** and **extension** of their **interactions in time** could be helpful in both cases.

A) **Stakeholder integration** involves an extension of control and can be:

- *Vertical*: a single stakeholder responsible for the whole product life cycle phases, e.g. a producer of washing machines as well as recycler of the washing machines
- *Horizontal*: one stakeholder is responsible for different products and services within one system of satisfaction, e.g. a producer who sells washing machines as well as washing powder and later deals with their end-of-life treatment

Without going too deeply into this topic we must mention that vertical and horizontal integration also have their own limits due to monopolistic risks and inefficiency enabled by the absence of concurrency.

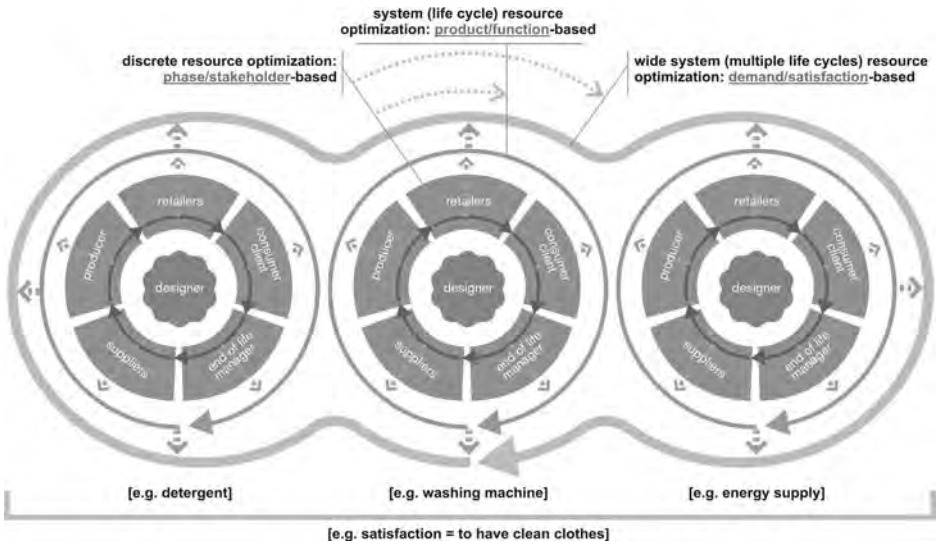
But the extension of control is not the only way to modify the interactions.

B) **Extending the duration of interactions** and partnerships means that relations between stakeholders do not end with the transaction or sale of the (pre)product:

- *Vertical*: more stakeholders, including the final user, extend their interactions within a given product life cycle
- *Horizontal*: more stakeholders, including the final user, extend their interactions within a particular system of satisfaction

Figure 2.2 **Convergence scheme between the interests of stakeholders in a satisfaction system, working towards system sustainability**

Source: derived from UNEP 2002



In the following section we will see which typology of stakeholder interaction may lead to eco-efficient system innovation.

2.1.4 Eco-efficient PSS innovation typologies

Three major business approaches to system innovation have been studied and listed as favourable for eco-efficiency (UNEP 2002; UNEP 2009):

1. Product-oriented PSS: services providing added value to the product life cycle
2. Result-oriented PSS: services providing 'final results' for customers
3. Use-oriented PSS: services providing 'enabling platforms for customers'

Product-oriented PSS: adding value to the product life cycle (type I)

Let us start with an example of an **eco-efficient** system innovation adding value to the product life cycle.

Klüber lubricants service

Klüber has moved from only selling lubricants to commercial customers to a service providing added value to product use. Using a service called S.A.T.E. Klüber analyses the effectiveness of aerosol treatment plants and sewage treatment. For this purpose, Klüber has designed a movable chemical laboratory, a van that is able to monitor a client's industrial machines directly, to determine the performance of lubricants used and their environmental impact. It also controls noise, vibrations, smoke and many other undesirable industrial impacts. The additional service Klüber offers clients leads to plant improvement in terms of efficiency, guarantees functionality and durability, and enhances environmental protection.

Klüber has broken away from the business-as-usual attitude. Its interests do not rely only on the amount of lubricant sold, but also on service; in fact there has been a reduction in the overall quantity of lubricant consumed per unit of service and thus a reduction in polluting emissions. Other benefits arise from the improved monitoring of performance of various machines, so that any accidental pollution can be avoided. Clients perceive they derive added value from this service because it frees them from the costs and the problems associated in the monitoring and checking of their equipment. Achieving better efficiency from lubricants also provides many economic benefits both in production processes and in improving the life of machines, and plant costs are also reduced.

In summary, a **Product-oriented PSS innovation adding value to the product life cycle** is defined as:

> **a company (alliance of companies) that provides additional services to guarantee an extended life cycle performance of the product/semi-finished product (sold to the customer).**

A typical service contract would include maintenance, repair, upgrading, substitution and product take-back services over a specified period of time.

This reduces the user's responsibility in the use and/or disposal of the product/semi-finished product (owned by her/him), and the innovative interaction between the company and the customer drives the company's economic and competitive interest in continuously seeking environmentally beneficial new solutions, i.e. the economic interest becomes something other than only selling a larger amount of products.

Result-oriented PSS: offering final results to customers (type II)

The following describes an example of an eco-efficient system innovation providing final results to customers.

The 'solar heat service'—pay per hot water

The 'solar heat service' is a full-service providing a final result, consisting of 'selling' hot water as a finished product. Hot water is produced by new equipment that combines sun, energy and methane, with economic and energy savings. Solar plants are designed in order to maximise the contribution of solar energy. Hot water is measured by means of a specific heat meter, and the whole system is monitored in order both to control in real time how the system works and also to apply a Guarantee of Solar Results, a specific contract through which the installer makes a commitment to reach a pre-determined level of efficiency. AMG has already tested this service in a Tennis Club in Palermo, Italy, providing hot water for the dressing rooms. The innovative feature of this Product-Service System is that AMG will not invoice the client for the methane consumed to obtain hot water, but rather, hot water is sold as an entire service. AMG sells heat and calculates the thermal kilowatts consumed by its clients. With AMG the consumer pays for receiving a comprehensive service, from installation, to the thermal-energy meters, and to the transportation of methane to the boilers. With equipment maintenance provided as well, the customer is overall buying a 'final result'.

This new product-service mix is sold as a complete service, which can significantly benefit the environment. The company thus becomes motivated to innovate in order to minimise the energy consumed in use. Billing is by unit of service and not per unit of consumed resources. The less methane consumed (the higher the use of solar energy and the system efficiency) the higher the income for AMG.

A **result-oriented PSS innovation offering final results to customers** can be therefore defined as:

> **a company (alliance of companies) that provides a customised mix of services (as a substitute for the purchase and use of products), in order to provide an integrated solution to meet a particular customer's satisfaction (in other words a specific final result). The mix of services does not require the client to assume (full) responsibility for the acquisition of the product involved. Thus, the producer maintains the ownership of the products and is paid by the client only for providing the agreed results.**

The customer does not own the products and does not operate them to achieve the final satisfaction; the client pays the company to provide the agreed results. The customer benefits by being freed from the problems and costs involved in the acquisition, use, and maintenance of equipment and products. The innovative interaction between the company and the client drives the company's economic and competitive interest to continuously seek environmentally beneficial new solutions, e.g. long-lasting, re-usable and recyclable products.

Use-oriented PSS: offering enabling platforms for customers (type III)

Finally, the following box describes an example of an eco-efficient system innovation as enabling platforms for customers.

Car sharing—Move About by Th!nk

Move About, like many other car-sharing systems, is a service providing an enabling platform of product (car) and services. It 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). For car users, a subscription to a car-sharing system provides convenient access to car mobility at lower costs than a traditional car rental agency. The local administration offers various incentives, such as free parking, exemption from road pricing and authorisation to drive in bus lanes.[1] A car-sharing system basically intensifies the use of cars, meaning a lower number of cars are needed in a given context for a given demand for mobility.

In summary a **use-oriented PSS innovation offering an enabling platform to customers** is defined as:

> **a company (alliance of companies) offering access to products, tools, opportunities or capabilities that enable customers to meet the particular satisfaction they want (in other words efficiently satisfying a particular need and/or desire).**
>
> **The customer obtains the desired utility but does not own the product that provides it and pays only for the time the product is actually used. Depending on the contract agreement, the user could have the right to hold the product/s for a given period of time (several continuous uses) or only for one use. Commercial structures for providing such services include leasing, pooling or sharing of certain goods for a specific use.**

The client thus does not own the products and does not operate them to obtain the final satisfaction (the client pays the company to provide the agreed results). Again in this case the innovative interaction between the company and the client drives the company's economic and competitive interest to continuously seek environmentally beneficial new solutions, e.g. to design highly efficient, long-lasting, re-usable and recyclable products.

1 See www.mindsinmotion.net/index.php/mimv34/themes/hybrid_electric/featured/move_about

2.1.5 Eco-efficient PSS potential

All three types of eco-efficient PSS innovation approaches discussed so far (adding value to the product life cycle, offering final results to customers, and offering enabling platforms to customers) present environmentally and economically favourable solutions. In fact, these and other examples show that innovative interaction between the client and the providers and other system production chain stakeholders can reach mutually beneficial solutions, where the same economic interest that led towards innovations reduces the environmental impact.

The bottom line is that, compared to a traditionally produced product, a company can make more money if it can meet the same demand by providing a less resource/service intensive product and related service mix. Cost savings for the producer/service-provider result from reduced quantities of product materials, streamlined managerial costs, and reduced costs from prolonged responsibility for the product, throughout its use and disposal. Of course these potential reductions must be balanced against the possible increase in costs of servicing, transportation, disposal and recycling. In fact, today the cost of labour in industrialised countries may represent a significant barrier for a shift to PSS.

During the **use phase**, the producer has a potential economic interest to reduce the amount of resources consumed, because profit is dependent on the amount being paid per unit of service provided to the customer. Furthermore, since the producer remains the 'owner', or at least retains some responsibility for the product over its life cycle, there is a further economic incentive to extend a product's lifetime. In this way the producer in essence postpones both the disposal costs and the costs of manufacturing a new product.

At the **end of** a product's **life**, the producer has the potential economic interest to re-use or re-manufacture components of disposed products to save on landfilling and new product manufacture. Furthermore, the producer will be motivated to look into other ways to extend material life, such as recycling, energy recovery or composting.

The potential eco-efficiency of the system innovation therefore depends on those economic interests of the stakeholder that favour:

- Product life cycle optimisation, designing to extend the product (and its components') life span and to intensify product (and its components') use[2]
- Materials' life extension, designing in order to valorise material from scrapped products, such that rather than ending up in landfills, they can be

2 Intensifying usage means that a (greater) number of people use the same product (or component) at different times. A product used more intensely than others leads to a reduction in the quantity of product present at a given time or in a given place in order to meet a given/the same demand for a function; i.e. it determines a reduction in environmental impact.

re-processed to obtain new secondary raw materials or incinerated to recover their energy content

- Minimisation of utilised resources, design aimed at reducing the usage of materials and energy of a given product or, more precisely, of a given service offered by that type of product

System eco-efficiency is also increased with:

- Easily adoptable technologies, because the service providers may avoid higher initial investment, e.g. new efficient technology
- Fast substitution of obsolete products with new and more eco-efficient one

2.1.6 PSS benefits for producer/provider and customer

In this section we describe the main benefits seen by the customer and the producer/supplier.

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

The advantage on the customer side is a higher level of productivity because of better utilisation of the product's performance and the longer operation possibility. For most reported PSS cases, the customer receives value in a form that is close to current needs; while innovative forms of value are suggested as being possible, few real-life examples are present.

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

More specifically, an improved strategic positioning could be achieved as a result of:

- **New market development**, i.e. a differentiated offer of a new product-service mix providing added value to consumers compared to a product alone; common in industrialised economies
- **Increased flexibility** to respond more rapidly to the changing consumer market, due to new outsourcing relationships
- **Longer-term client relationships** which lead to stronger company/customer relationships and thereby customer retention

- **Improved corporate identity** to respond to the demands for a company to be 'responsible and transparent', by showing its environmental and social benefits
- **Improved market and strategic positioning** because of existing and future environmental legislative requirements or restrictions, e.g. Extended Producer Responsibility, resource taxes, environmental performance

2.1.7 PSS eco-efficiency limits and constraints

Not all PSSs are eco-efficient

It is important to underline that not all shifts to PSS result in environmental benefits: a PSS must be specifically designed, developed and delivered, if it is to be highly eco-efficient. For example, schemes where products are borrowed and returned incur transportation costs (and the resultant use of fuel as well as pollution emissions) over the life of the product. In some specific instances, the total fuel cost and environmental impact may make the system non-viable in the long term.

Furthermore, even when well designed, it has been observed that some PSS changes could generate unwanted side effects, usually referred as **rebound effects**. Society as a whole is a set of complex, inter-related systems that are not clearly understood. As a result, something may happen that turns potential environmentally sound solutions into increases in global consumption of environmental resources at the practical level. One example is the impact of PSS on consumer behaviour. For example, outsourcing, rather than ownership of products, could lead to careless (less ecological) behaviours.

Nevertheless, PSS development seen as a whole presents great potential for generating win–win solutions that promote profit and environmental benefits. It has the potential to provide the necessary, if not sufficient, conditions to enable communities to leapfrog to less resource-intensive (more dematerialised) systems of social and economic systems.

Finally, it is simply better to avoid uncritical research, assuming that new system innovation will automatically produce environmentally friendly solutions without being adequately equipped with enough sensitivity, conceptual vocabulary and operational tools that would allow actual re-orientation towards sustainability and sustainable goals. This means on an operative level we need criteria, methods and tools to orientate design towards system eco-efficient stakeholder interactions and relationships.

Barriers to adopting eco-efficient PSS innovation

Most products involve services and vice versa; change towards a service economy has been ongoing for decades. In other words, PSS is nothing new. Why, then, are eco-efficient PSSs not yet diffused?

The main barrier to adopting eco-efficient PSSs (in industrialised contexts) is the cultural shift necessary for the user to value 'having a need or want met in a sustainable way' as opposed to 'owning a product'. This cultural leap can be made, but it is not straightforward for a consumer or intermediary retailer (as a client) to understand. Wong (2004) argues that to be successful a PSS solution in the consumer market must be sensitive to the culture in which it will operate. He notes that PSS solutions have been more readily accepted in the communal societies of Scandinavia, the Netherlands, and Switzerland.

Businesses face barriers in the design, development and delivery of PSSs, in implementing the changes required in corporate culture and organisation, to support a more systemic innovation and service-oriented business. In this regard, it has been observed that some companies in mature industries see it as an opportunity to survive, while others see it as a way of gaining entry to a new sector.

A further obstacle for business 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. Other barriers faced by business include lack of knowledge and experience in terms of:

- Service design methods and tools
- New tools which companies can use to orientate, assess and implement eco-efficient PSSs
- Service management systems
- Entrepreneurial personnel who are skilled in service development and provision
- Life-cycle costing methods

Furthermore, businesses may perceive the risks of:

- Conflict with existing internal procedures and tools, e.g. accounting and reporting methods
- A service being easily replicated by a competitor (more easily than a physical product)
- Partnerships and entrepreneurial interdependence leading to reduced control of core competences and reducing the influence of business decisions

Finally, barriers to be overcome may include a lack of external infrastructure and technologies, e.g. for product collection, remanufacturing or recycling.

Per stakeholder type, barriers for the eco-efficient PSS diffusion in industrialised contexts are summarised as follows (Ceschin 2010):

- For *companies* the adoption of a PSS strategy is more complex to be managed than the existing way of delivering products alone. There is a need to

implement changes in corporate culture and organisation in order to support a more systemic innovation and service-oriented business (UNEP 2002); there is indeed resistance by companies to extend involvement with a product beyond point-of-sale (Stoughton *et al.* 1998; Mont 2002). Extended involvement requires new design and management knowledge and approaches. It requires medium-to-long-term investments and is therefore connected with uncertainties about cash flows (Mont 2004). Moreover, a further obstacle is the difficulty of quantifying the savings arising from PSS in economic and environmental terms, in order to market the innovation to stakeholders both inside and outside the company, or to the company's strategic partners (UNEP 2002). Finally, the significant change in the system of earning profit could deter producers from employing the concept, first through limited experience in pricing such an offering, and second through fear of absorbing risks that were previously assumed by customers (Baines *et al.* 2007)

- For *customers/users*, the main barrier is the cultural shift necessary to value an ownerless way of having a satisfaction fulfilled, as opposed to owning a product (Goedkoop *et al.* 1999; Manzini, Vezzoli and Clark 2001; Mont 2002; UNEP 2002). Solutions based on sharing and access contradict the dominant and well-established norm of ownership (Behrendt *et al.* 2003); this is especially true in the B2C market, while in the B2B sector numerous examples of eco-efficient PSS concepts can be identified (Stahel 1997). Product ownership not only provides function to private users, but also status, image and a sense of control (James and Hopkinson 2002). Another obstacle is the lack of knowledge about life cycle costs (White *et al.* 1999), which makes it difficult for a user to understand the economic advantages of ownerless solutions
- For *governments*, on the *regulatory and policy side*, actual laws may not favour PSS-oriented solutions. Environmental innovation is often not rewarded at the company level due to lack of internalisation of environmental impacts (Mont and Lindhqvist 2003). In addition there are difficulties in implementing policies to create corporate drivers to facilitate the promotion and diffusion of this kind of innovation (Mont and Lindhqvist 2003; Ceschin and Vezzoli 2010)

Assuming a broader perspective, we may observe that a diffused inertia regarding consolidated habits is limiting eco-efficient PSS innovation. Namely, PSSs are not simply a leapfrog business strategy: a transition path is often needed.[3] Furthermore, and perhaps most importantly, there is a lack of knowledge on eco-efficient PSS design: we need a new generation of designers (and design educators) and other professionals capable of operating with complex system research and innovation.

3 See Part 2, Section 1.

2.2 Product-Service Systems for emerging and low-income contexts

2.2.1 Can PSS be a promising concept for emerging and low-income contexts?

In 2000 the United Nations Environment Programme (UNEP) set up a group of international researchers[4] to both disseminate worldwide the concept of Product-Service Systems innovation and start exploring new PSS potentialities, which can be summed up in the following queries.

Is Product-Service System innovation (PSS) also applicable in emerging and low-income contexts?

This question arose simply because the development of Sustainable Product-Service Systems studied and achieved thus far did not refer to the socio-ethical dimension of sustainability nor specifically to emerging and low-income contexts (which are by statute within the concern of the United Nations Environment Programme).

This question is the forerunner of another.

(If the answer to the first is affirmative) can a PSS approach favour social equity and cohesion within these contexts together with eco-efficiency? And if so, with what particular characteristics?

The response to the former two questions given by the international group of experts engaged by UNEP was the following working hypothesis:

> PSS (system innovations) may act as business opportunities to facilitate the process of social-economic development in emerging and low-income contexts—by jumping over or by-passing the stage of individual consumption/ownership of mass produced goods—towards a 'satisfaction-based' and low-resource intensive advanced service economy (UNEP 2002).

To clarify this working hypothesis let us look at an example of Product-Service System innovation in a low-income/emerging context.[5]

4 The work involved a group of researchers (including the author) from industrialised, emerging and low-income countries; it was set up in 2000 and ended in 2002 presenting the main achievements within the publication UNEP (2002) *Product-Service Systems: Opportunities for Sustainable Solutions*.

5 The cases presented in this chapter come from the previously mentioned UNEP booklet of 2002 and from a case databank of the WBCSD, both freely available on their respective websites (www.unep.fr/scp/publications/details.asp?id=WEB/0081/PA and www.wbcsd.ch/publications-and-tools.aspx).

Distributed Solar Energy and electrical devices as an all-inclusive package, Brazil

In 2001, Fabio Rosa began exploring a new business model to provide Brazil's rural people with what they needed: energy services, not just solar energy. Rosa founded both a for-profit corporation, Agroelectric System of Appropriate Technology (STA), and a not-for profit organisation, the Institute for Development of Natural Energy and Sustainability (IDEAAS). To that end TSSFA developed a leasing structure whereby customers pay a monthly fee for the use of cost-effective solar energy packages, a basic photovoltaic solar home system that could be rented for US$10/month plus an initial installation fee. This not only fits with the traditional way people pay for energy, it also saves its customers from paying the 50% sales tax that would be required if they were to purchase the systems instead of renting them. Solar home kits, as TSSFA calls them, include the hardware needed to generate energy, while also providing the installation service and products that use the electricity generated by the solar home system, such as lighting and electrical outlets. All of the tangible inputs are owned by STA and only the services provided by these materials are leased to customers.

The case illustrates Product-Service System innovation as an approach applicable in emerging and low-income contexts. The following arguments can be highlighted in support of this hypothesis (UNEP 2002).[6] First, if PSSs are eco-efficient at the system level it means that they may represent opportunities for a context with fewer economic possibilities to respond more easily to unsatisfied social demands with lower overall costs, as can be seen in the case studies described above.

Second, PSS offers are more focused on the context of use, because they do not only sell products: they open (and/or lengthen) relationships with the end user. For this reason, an increased offer in these contexts should trigger a greater involvement of (more competent) local, rather than global, stakeholders, thus fostering and facilitating the reinforcement and prosperity of the local economy.

Furthermore, since PSSs are more labour and relationship intensive, they can also lead to an increase in local employment and a consequent dissemination of skills.

Finally, since the development of PSSs is based on the building of system relationships and partnerships, they are coherent with the development of network enterprises on a local basis for a bottom-up re-globalisation process. This last issue is clarified in the next section where the model of *distributed economies* is introduced.

6 This hypothesis has also been examined in a series of case studies, collected by the group engaged by UNEP.

2.2.2 Distributed economies: a promising economic model for PSS innovation coupling eco-efficiency with social equity and cohesion

Assuming, as argued and exemplified above, that the PSS approach is applicable to emerging and low-income contexts, a second research question was proposed:

What characteristics does a PSS need in order to foster eco-efficiency together with social equity and cohesion within emerging and low-income contexts?

In this section we argue that an answer to this question could be provided by coupling the two models of *PSS* and *distributed economies*. Similarly to PSS, several authors have argued that *distributed economies* can be a favourable economic model to couple socio-ethical and environmental dimensions of sustainability (Mance 2001; Rifkin 2002; Sachs *et al*. 2002; Johansson *et al*. 2005; Vezzoli and Manzini 2006; Crul and Diehl 2006; Rifkin 2010). The International Institute for Industrial Environmental Economics (IIIEE) in Lund defines distributed economies as a 'selective share of production distributed to regions where activities are organised in the form of small scale, flexible units that are synergetically connected with each other' (Johansson *et al*. 2005).

The mainstream economic model of industrialised contexts, characterised by centralised and large-scale production units, determines dynamics that undermine sustainability, both on environmental and socio-ethical levels. Examples of such dynamics include:

1. Increasing the movement of raw materials and products over longer distances, mainly relying on decreasing unit transportation costs
2. Distancing production from consumers and thereby hiding the environmental and social costs (Dahlberg and Jansson 1998)
3. Weakening the local actors' possibilities to have ownership and control over their immediate economic environment
4. Distorting or destroying cultural identities
5. Limiting diversity in regional economic activities (Johansson *et al*. 2005)

Besides these disadvantages, being large-scale and centralised limits the ability of such production units to respond to rapidly changing demand. In recent decades the adjective *distributed*[7] has been increasingly used in relation to several socio-economic systems: information technologies and *distributed computing*; energy systems and *distributed energy generation*; production and the possibilities of *distributed manufacturing*; and the processes of change and *distributed innovation, distributed creativity, and distributed knowledge*. Finally, in relation to overall

7 To distribute: to divide something into portions and dispense it (from Wiktionary, the wiki-based Open Content dictionary).

socio-technical systems, the term has been used to describe the new economic model of *distributed economies*.

Some of these concepts became mainstream two decades ago (i.e. the 'classic' distributed computing). Some have a strong position in the international arena (such as the concepts of distributed energy generation and distributed manufacturing). Some have emerged, and are emerging, in recent years and have a wide and growing audience (distributed innovation, distributed creativity, and distributed intelligence). In all these cases, what the term *distributed* adds to the substantive to which it is related is the idea that it has to be considered as a web of interconnected, autonomous elements, i.e. elements that are capable of acting autonomously, being, at the same time, highly connected with the other elements of the system.

Let us now look at the fossil fuel resources model from an economic and socio-ethical point of view. Resources from fossil fuels, due to their localisation and the complexity of extraction and transformation processes, have led to a series of highly centralised production and distribution infrastructures, reducing opportunities for access to resources, above all to energy and particularly electricity. It is therefore claimed that the enlarging rift between rich and poor can to a large extent be attributed to the very nature of the fossil fuel energy regime (Rifkin 2002).

As an alternative to fossil fuel, the use of renewable, local resources, such as sun, wind and hydrogen, presents indubitable environmental advantages, due to their reduced greenhouse effect (and its impact), inexhaustibility and lower environmental cost compared to the various processes of extraction, transformation and distribution when using fossil fuels. They are installable and manageable by *small-scale economic entities*, even by a single residential complex or single individuals. If adequately exploited, sun, wind and other renewable sources of energy would enable every human being to have more power and move towards a democratic regime of resource management. Such a decentralised infrastructure supplied by renewable sources, usually referred to as *distributed energy generation*, on the one hand would reduce environmental impact and on the other could facilitate a democratisation of resources and energy, enabling individuals, communities and nations to reclaim their independence while accepting the responsibility that derives from their reciprocal interdependence (self-sufficiency and interdependence).

Renewable energy sources have the characteristics that lead to low environmental impact, decentralised and democratic production systems, but all this may not necessarily happen.

Whether in industrialised, emerging or low-income contexts it will be essential to develop the capacity to gather large masses of producer-users into networks and associations with an adequate, decentralised, bottom-up institutional approach, in order to guarantee more control to community members and power over their

own destiny: for example, in low-income contexts, village cooperatives in collaboration with micro-credit banks.[8]

More generally we can observe that in an interconnected context a principle that double ties the environmental question to social ethics can be summarised as follows:

> use primary local, conservative, regenerative (i.e. locally sustainable) resources and introduce decentralised system networks for the extraction, production and use of those resources.

It has also been observed (Sachs *et al*. 2002; Sachs and Santarius 2007) that when there are local stakeholders involved in the extraction, transformation and sale of resources, then they pay far more attention to preserving (resource) renewability. The obvious underlying reason is that their economic subsistence depends, in the short but also in the long term, on these resources. Therefore they are not in favour of exhausting them quickly.

This theme intertwines with other points of interest in research on so-called forms of alternative economy or alternative enterprises, founded on the concepts of cooperation, collectivity and collaboration (the so-called C factor, Razeto 2002). In particular, it merges with research on *cooperative networks* and *creative communities* (Florida 2002; Manzini and Jegou 2003), characterised by the self-organised activities of aware, critical, motivated citizens who are organised to a greater or lesser extent into networks and solidarity economy districts. It is thereby linked to work on those forms of sustainable social innovation, i.e. solutions of high social quality and low environmental impact, that spring from active, bottom-up social participation.

Euclides Mance approaches the issue from a more solidarity economy-based background. Mance talks about *solidarity cooperative networks* (Mance 2001) as 'networks in which units of production and consumption are articulated in self-propagating and self-feeding nodes in a solidarity collaboration'.

These models can fit under the wide umbrella of distributed economies, having two main characteristics:

- They are *locally based*, i.e. enterprises or initiatives based on sustainable local resources and needs, but could become open to non-local or global systems

8 On a worldwide level, cooperatives are the best organised vehicles to set up and diffuse such economies, able to acquire local resources and make them operative, without the aid of huge transnational companies. Cooperatives are organised on a geographical basis, gathering single producers and consumers together in a participatory non-profit institution. According to the ICA (International Co-operative Alliance) the principles of cooperatives are: the universality of associate member qualification, democratic participation, fair distribution of resources, autonomy, training, cooperation between cooperatives and community commitment. Aggregation of single consumers (and producers) allows them to deal with their suppliers from a position of greater strength (collective bargaining).

- They are *network-structured* enterprises or initiatives, i.e. they can gain critical mass and potentialities by their connections in networks

Finally, to answer the question posed at the beginning of this section the following research hypothesis could be formulated, characterising the former assumption of PSS being applicable to emerging and low-income contexts:

> A Product-Service System innovation (PSS approach) may act as a business opportunity to facilitate the process of social-economic development in an emerging and low-income context—by jumping over or by-passing the stage of individual consumption/ownership of mass-produced goods—towards a more 'satisfaction-based' and low resource intensity advanced service-economy, *characterised by locally based and network-structured enterprises and initiatives, for a sustainable re-globalisation process aiming to democratise access to resources, goods and services.*

In this framework the definition of **a sustainable PSS** proposed by the LeNS project runs as follows:

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

3

Product-Service System design for sustainability

3.1 PSS design for sustainability: a definition

After understanding the opportunities offered by PSS to product/service development, it is time to lead our argumentation towards the role of the designer.

Let us start with a definition of (industrial) design, the one given by the International Council of Societies of Industrial Design (ICSID).[1]

> Design is a creative activity whose aim is to establish the multi-faceted qualities of objects, processes, services and their systems in whole life-cycles […]. Design seeks to discover and assess structural, organisational, functional, expressive and economic relationships, with the task of:

- Enhancing global sustainability and environmental protection (global ethics);
- Giving benefits and freedom to the entire human community, individual and collective;
- Final users, producers and market protagonists (social ethics);
- Supporting cultural diversity despite the globalisation of the world (cultural ethics);
- Giving products, services and systems those forms that are expressive of (semiology) and coherent with (aesthetics) their proper complexity.

1 Definition since 2005, see www.icsid.org.

Particularly relevant to our discussion is that, unlike previous definitions, it considers systems within the scope of design, not only products and processes. In addition, promoting the idea that design considers the 'whole life cycle' makes significant reference to environmental issues.

This definition differs in many ways from the one given by Tomàs Maldonado from the same organisation 40 years ago: 'By industrial design we normally mean the designing of industrially manufactured objects.'

Moreover the new definition includes a PSS approach to sustainability that addresses the widening possibilities for innovation beyond the product, particularly innovation, as we saw, characterised by being:

- Developed/designed and delivered in relation to a particular customer 'satisfaction'
- Radical innovations, not necessarily technological ones, as new interactions/partnerships between the stakeholders of a particular satisfaction production chain
- Innovation in which it is the company/companies' economic and competitive interest that may lead to an environmental impact reduction (system eco-efficiency)

Having understood this, **Product-Service System Design for Sustainability** is defined as:

> **the design of the system of products and services that are together able to fulfil a particular customer demand (deliver a 'unit of satisfaction') based on the design of innovative interactions of the stakeholders (directly and indirectly linked to that 'satisfaction' system) where the economic and competitive interest of the providers continuously seeks both environmentally and socio-ethically beneficial new solutions.**

3.2 PSS design for sustainability: approaches and skills

Thus far, the introduction of PSS innovation for sustainability into design has led design researchers to work on defining new skills of a more strategic nature, which aim at system sustainability through a strategic convergence of interests and are coherent with the *satisfaction-based* approach. 'Strategic' here also refers to the necessary acknowledgement of cultural contexts and inherent opportunities and barriers built into the social fabric. Design research in Asian contexts, for example, take into account traditions and values systems that have underpinned societies for millennia.[2]

2 See Section 3.5 in this chapter for an elaboration on PSS Design for Sustainability in Asian contexts.

In synthesis, the main approaches and skills of **Product-Service System Design for Sustainability** are:

- A **satisfaction-system** approach, i.e. the design of the satisfaction of a particular demand (satisfaction unit) and all its related products and services
- A **stakeholder configuration** approach, i.e. the design of the interactions of the stakeholder of a particular satisfaction-system
- A **system sustainability** approach, i.e. design of such stakeholder interactions (offer model) that continuously seeks new, beneficial eco-efficient and socially equitable, locally based and cohesive solutions

These key elements will be further explored in the following sections.

3.2.1 The design of particular *satisfaction*

The first key point lies in the satisfaction-based approach where the focus is no longer on a single product. It is thus inadequate to merely design or assess a single product, but instead we consider the whole process of every product and service associated with satisfying certain needs and/or desires.

To clarify this concept we can recall the earlier example (UNEP 2002) where the unit of satisfaction was 'having clean clothes', a unit for which we need a washing machine as well as detergent, water and electricity (and the services that supply them), and maintenance, repair and disposal services. The term *satisfaction* is proposed to emphasise the enlargement of the design scope from a single product to the system of products and services (and related stakeholders) that together meet a given demand of needs and desires: in fact a particular **demand for satisfaction**.

The use of this terminology is corroborated by other authors. Meadows (Meadows, Meadows and Randers 2006), for instance, uses satisfaction in a formula[3] to evaluate the limits of growth, in the 30-year update of the previous *Limits to Growth* publication commissioned by the Club of Rome and known worldwide, which had modelled the consequences of a rapidly growing global population and finite resource supplies. Marks *et al.* (2006) argue that among various indicators measuring personal well-being in the framework of transition towards sustainability, satisfaction seems to be preferable.

Finally, in parallel with the introduction of the concept of the *functional unit* (see Introduction) for product *Life Cycle Design*, a **satisfaction unit** could be introduced. If we take the example of a car the following *functional unit* could be defined: the transportation of one person per km (possible with a car). If we consider the

3 In *Limits to Growth: the 30-Year Update* (Meadows, Meadows and Randers 2006) the following formula is used:
Resource & Energy/per year = # of people (**Satisfaction**/Person – Year) Resource & Energy/Per **satisfaction**).

satisfaction that a car could provide, we may in fact identify several satisfaction units, for example:

- Satisfaction unit 1: one person having access to her/his working space (per year)
- Satisfaction unit 2: one person having access to public services delivering personal documents (per year)

The concept of a satisfaction unit therefore requires an approach that is at the same time:

- Wider (more products, services, stakeholders to be considered)
- Narrower (looking at one final customer satisfaction)

In the words of Ehrenfeld (2008) a satisfaction approach in design 'is to think more on being (satisfied), rather on having (products to be satisfied)'.

3.2.2 The design of stakeholder interactions

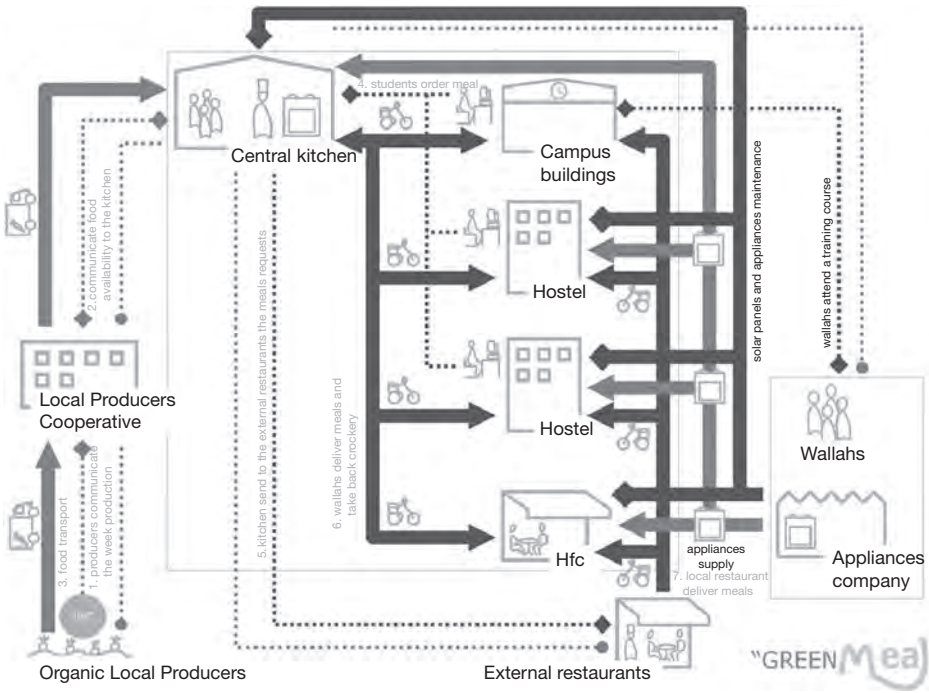
The second key task is to introduce a *stakeholder configuration* approach. If we want to design the *stakeholder interactions*, the system design approach should project and promote innovative types of interactions and partnerships between appropriate socio-economic stakeholders, while responding to a particular social demand for satisfaction.

To clarify this approach we can again recall the example of clean clothes, where the innovation involves all the different socio-economic stakeholders in this satisfaction system: the washing machine and detergent producers, the water and electricity suppliers, the user and those responsible for maintenance and disposal.

To visualise the mode of approach it may be useful to think of and draw a parallel with the design questions that more typically concern a *traditional* designer, who in designing a product defines the technical, performance and aesthetic characteristics of its components and its connections, in order to describe the configuration of the product components that are not characterised by materials (with specific performance functions) and by their connection systems (joining elements). In this way a systems designer for sustainability must imagine and promote innovative types of *connections*—partnership/interaction—between appropriate components—socio-economic stakeholders—of a system responding to a particular social demand for satisfaction. In other words the components of a satisfaction system are characterised by socio-economic stakeholders (with their skills and abilities) and by the interaction occurring between them (partnerships, or more generally, interaction). Therefore designing the configuration of a system means understanding who the best stakeholders (components) are and what the best interrelationships (connections) are.

Figure 3.1 shows a PSS design tool, the *stakeholder system map,* as an example of a design and visualisation tool focused on and aimed at facilitating a stakeholder configuration design.

Figure 3.1 **Stakeholder system map, in this example related to eating satisfaction within a university campus canteen**



3.2.3 The design of a sustainable stakeholder interaction system

It must be re-emphasised that, as stated in the previous chapter, not all system innovations are eco-efficient and/or socially equitable and cohesive. We must remain critical and reflective, in order to avoid the intuitive assumption that any obtainable PSS innovation naturally carries the potential for sustainable development.

For this reason, in terms of the development of new systems it is expedient to operate and adopt appropriate criteria and guidelines. This brings up the great importance to study cases, methods and tools to manage and orientate the design process towards sustainable stakeholder interactions/relationships.

In the clean clothes example, the new stakeholder system configuration could be e.g. towards a pay per wash system (unit satisfaction) and include home delivery of a washing machine (not owned), electricity supply (not directly paid), water supply (not directly paid), detergent supply (not directly paid), maintenance, upgrading and end-of-life collection. The innovative interaction between the companies

and the client drives the companies' interest to design and provide highly efficient (for energy, water and detergent), long-lasting, re-usable and recyclable washing machines.

These approaches require skills and abilities that are relatively new for a designer, but as we stated earlier they are connected to the disciplinary area known as *strategic design* (e.g. Manzini, Collina and Evans 2004), an area already endowed with its own body of theory and its own methods and tools.

For this reason the expression *strategic design for sustainability* has been brought into use (Manzini and Vezzoli 2001). As such considerations give rise to a convergence of *Product-Service System Design for Sustainability* with both *strategic design* and *product Life Cycle Design,* it has also been argued (Brezet *et al*. 2001; Manzini and Vezzoli 2001) that design for environmental sustainability must use and integrate the methods and tools of strategic design (and vice versa).

From this perspective on design, which takes into account all simultaneously active socio-economic stakeholders, designers must likewise equip themselves with the necessary skills to operate in a participatory design context (i.e. among various entrepreneurs, institutions, NGOs, associations and services) for system development that includes the offer (products and services).

As far as design practice is concerned, the first design methods and tools described here have been developed since the beginning of the 2000s, thanks to a series of EU-funded research projects, such as tools for the development of sustainability design-orienting scenarios, for the strategic convergence of different stakeholders, for interaction designing and for the generation of highly sustainable systems ideas. In Asian contexts, educators have been developing and testing tools and frameworks appropriate for and sensitive to local conditions and cultures.

A developed methodology and related tools are presented in Chapter 4.

3.3 Design criteria for and examples of system eco-efficiency

It has been already observed that not every system innovation is eco-efficient. Accordingly it is important to adopt appropriate criteria and guidelines as well as methods and tools for embedding them when designing a new system, in order to steer it towards a sustainable solution. Here we therefore propose several design criteria for system eco-efficiency.

As a starting point, as defined in the MEPSS[4] EU research project, six criteria can be listed according to their orientation towards eco-efficiency:

4 Developed in a European research project entitled MEPSS, Method for Product-Service System development, funded by EU, 5FP, Growth.

1. System life optimisation (section 3.3.1 below)
2. Transportation/distribution reduction (section 3.3.2)
3. Resource reduction (3.3.3)
4. Waste minimisation/valorisation (3.3.4)
5. Conservation/biocompatibility (3.3.5)
6. Toxicity reduction (3.3.6)

An organic set of guidelines developed within the LeNS project[5] for each of these criteria is presented in the appendix.

For a particular unit of satisfaction (e.g. having clean clothes as in the example mentioned), some criteria (and their related guidelines) have higher relevance than others when reducing the environmental impact (e.g. resource reduction and toxicity reduction have a higher priority compared to the other criteria). Therefore in a decision-making process (i.e. designing) it is important to identify the (eco-efficiency) design priorities: namely, the (relative) criteria most relevant in relation to the existing mix of products and services fulfilling a particular satisfaction unit, and which innovative stakeholders' interaction models are most promising with regard to meeting those criteria.[6]

The following sections will present these criteria together with examples.

3.3.1 System life optimisation

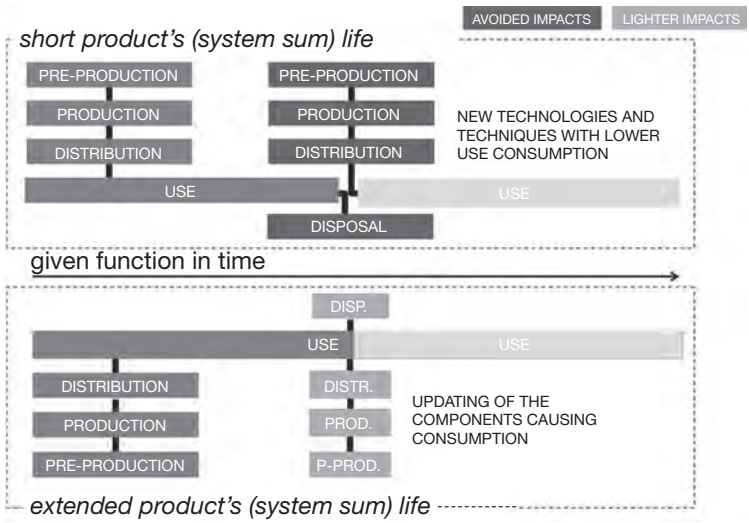
System life optimisation refers to the design *of stakeholder interactions* for a particular satisfaction *system* leading to **extending** the sum of the products' **lifespan** and **intensifying** the overall sum of the products' **use**.

A product with a *longer lifespan,* with otherwise similar functions, will generally secure a lesser impact on the environment. A product with a shorter life span will not only generate untimely waste (when the other is still functioning) but will also entail further impact due to the need to replace it (see Figure 3.2). Pre-production, production and distribution of the new product, which would cover the functions of the old one, induce further consumption of resources and creation of emissions. Figure 3.2 compares two products with the same functions but with different lifespans and shows in which precise phase it is possible to avoid these impacts. In other words, if we deliver a product with a longer lifespan compared with one with a shorter lifespan we avoid the impact occurring in the pre-production, production, distribution and disposal phases (see the upper part of Figure 3.2).

5 The LeNS project also developed and tested several other tools and guidelines that were sensitive to local particularities and cultural values. These approaches are described in more detail in Part 2 of this volume.

6 See e.g. Part 1, Chapter 4, Section 4.3.1 Sustainability Design-Orienting toolkit (SDO).

Figure 3.2 **Environmental advantages of a product (system sum) with a longer lifespan**



With regard to the usage stage, in reality extending the lifespan does not necessarily determine an overall reduction of the impact; on the contrary, there could be an increase if the new products are environmentally more efficient. In other words, for some products that have the greatest impact during usage, there could be an optimal length of lifespan. While providing the same service, technological development can therefore offer new, environmentally more efficient products (involving less consumption of energy and raw materials or emission reduction), and there would come a moment when the pre-production, production and distribution of a new product (and the disposal of the old one) would pay off, in terms of the environmental impact balance sheet, due to better performance during the usage stage.

Thus, there is a potential limit for the length of the lifespan, a breakeven point at which replacing the product with a new one (that provides the same service) results in less of a global impact. More precisely, the impact created due to the production/distribution of the new product and disposal of the outdated product is smaller than the reduction due to enhanced efficiency of the new product during use. The main candidates for longer lifespans are goods that consume fewer resources (energy or materials) during utilisation.

Let us look at the more critical case of products that consume large amounts of resources during usage and maintenance, for example, motor vehicles and home appliances. In these cases an interesting strategy could develop that would condition substituting only the components that determine consumption, i.e. enabling their replacement with new components embedding new technologies with lower use consumption. Thus, there would be no need to pre-produce, produce, distribute and dispose the entire product, but only those parts that would decrease the overall environmental impact (Figure 3.2).

Finally, on a system perspective (where we have more than one product) we have to consider the overall and interlinked environmental impacts of the whole of the product's or support products' (system sum) life duration and the potential to avoid environmental impacts.

Optimising the environmental system life can be achieved through *intensifying* the *usage* of the products.

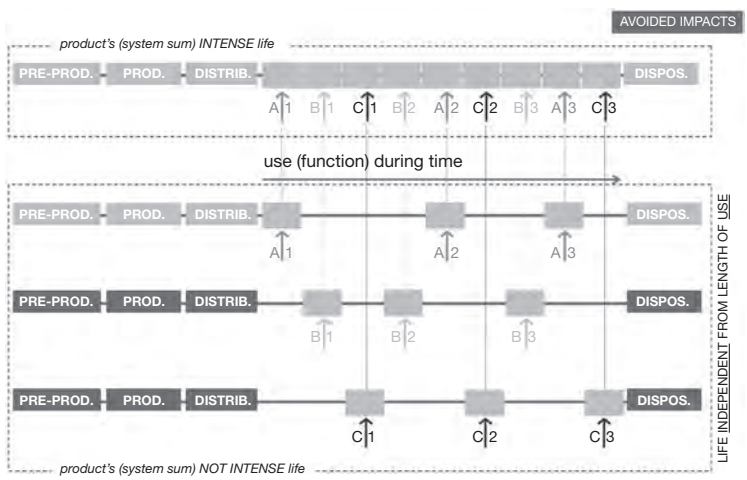
Any product used *more intensely* than other similar ones leads to a reduction in the actual number of those products at a given moment and place, while still answering the demand of their performance: this also determines the reduction in environmental impact. Let us clarify this concept with the help of some diagrams.

Starting with Figure 3.3, which assumes that the lifetime is independent of the actual usage of the product, let us imagine (see above the 'usage in time' arrow) that the product was intensely used by Andrew in periods A1, A2 and A3, by Bernard during B1, B2 and B3 and by Charlie in periods C1, C2 and C3.

Now let us imagine (see under the 'usage in time' arrow) another scenario where every participant has their own product and they use it during the same periods (assuming equal functionality). Schematically, it follows that the main impact is during the pre-production, production, distribution and disposal phases of the additional products. This is true only in the case when a product's lifetime does not depend on the time of actual usage, for example, due to obsolescence.

In other words, if products are used more intensely, their useful lifetime will pass faster without raising the global amount of products and their disposal. Thus, the more occasional the normal usage of the product and the higher its obsolescence (technological or aesthetic), the more the additional production can be reduced while still satisfying the same needs. Indeed, more intensive usage in general leads to a shorter absolute (time between acquisition and disposal) lifetime, but, on the other hand, it increases the time of effective usage (and reduces disposal due to obsolescence).

Figure 3.3 **Environmental advantages of intensifying the usage of the product's system sum (lifespan not dependent on the length of use)**

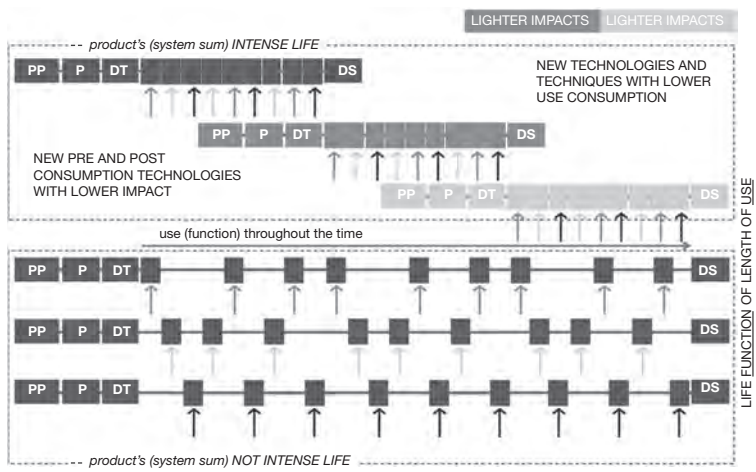


Let us turn to the case when a product's durability is related (inversely proportionally) to the actual usage, meaning that more intensive usage will effectively shorten its lifespan. Let us take the previous diagram and extend the timeline. Still reasoning with equal functionality (in these two scenarios Andrew, Bernard and Charlie use the products for the same periods of time), we must imagine the substitution of intensely used products (in Figure 3.4 we imagine two substitutions on top of the 'usage in time' line). However, in this case the environmental advantage results solely from the potential of technological progress (greater effectiveness of the pre-production, production, usage and disposal phases) that has become available.

Therefore, one outcome lies in the potential appearance of alternative technologies (with the possibilities of reducing impacts), without increasing the number of additional products to satisfy the same needs.

Moreover, we can also take the intensification into proportional account with the quantity of goods that are produced but not sold. In other words, the smaller the excess, the greater the intensity with which we use a certain productive batch.

Figure 3.4 **Environmental advantages of intensifying the usage of the product (lifespan dependent on the length of use)**



In qualitative terms, an existing system presents problems related to lifespan optimisation when:

- A disposable product or disposable support products are used
- Disposable packaging is used
- Parts of the system tend to be technologically obsolete
- Parts of the system tend to be culturally/aesthetically obsolete
- Some parts of the system tend to wear out more easily (than others)

PSS example of system life optimisation

EGO, Ecologico Guardaroba Organizzato (Organised Ecological Wardrobe)

EGO is an Italian company with two outlets in Brescia and Milan where they offer a system for the shared use of clothes between a closed number of women.

The user, after subscribing, selects 14 clothes (from a sample book) to be inserted in the 'shared wardrobe' (presently the 'shared wardrobe' includes 120 models, divided into eight different styles). Once a week the user goes to the outlet, chooses and withdraws seven pieces of clothing, and at the same time gives back the clothes used during the previous week. The member pays an annual registration fee of €170 plus a monthly subscription of €130. EGO takes care of washing and maintaining the clothes. EGO not only manages the service but also designs the clothes and manages the manufacturing (externalised to Italian companies).

The main environmental benefits are seen in the fact that a clothing sharing system basically intensifies the use of clothes, meaning that a lower number of clothes are needed in a given context for a given demand of clean clothes (system life optimisation through use intensification); in addition, since the producer/provider owns the clothes, they are economically interested in extending their lifespan in order to postpone the maintenance costs and costs for the disposal and manufacture of new products (system life optimisation through product life extension). As a consequence of the system life optimisation, there is a reduction in resources in terms of materials and energy used to produce, transport and dispose of the clothes. In addition the washing of clothes is done using high-efficiency washing machines (since this activity is managed by EGO, they are incentivised to reduce the cost of each single wash, therefore reducing the amount of energy and detergent used). On the other hand it has to be underlined that, compared to the traditional situation in which the user owns the clothes and manages the washing, in the EGO system the number of washes is higher (because clothes are washed after one single use).

3.3.2 Transportation/distribution reduction

Transportation/distribution reduction denotes the design of *system stakeholders' interactions* leading to a reduced amount of transportation and packaging. This type of innovation could be enabled for example by creating partnerships that optimise: long distance activities (use, maintenance, repair), use of local resources (info/data transfer), on-site assembly or production (info/data transfer), and/or remote controlling for maintenance/repair of products.

In qualitative terms an existing system presents problems related to transportation or distribution when:

- There is excessive transportation of goods
- There is excessive transportation of semi-finished products or by-products
- There is excessive transportation of people
- The transportation means in service are not fully used

PSS example of transportation/distribution reduction

Lampi di Stampa - book on demand

Lampi di Stampa offers a book-on-demand service in Italy based on a digital process comparable with offset printing. The innovation implies a transition from traditional offset printing to print-on-demand (i.e. digital). Offset technology involves the production of physical plates as well as the logistics for the delivery and stocking of the books. Digital print technology, on the other hand, essentially entails only one operation, printing the book directly from the file very near or even at the point of sale, hence avoiding several production and logistic phases. The environmental advantages are connected to the reduction in transport, the dematerialisation of some phases of the printing process, and the drastic reduction in the number of copies destined for maceration. In economic terms the print-on-demand process offers a guarantee on the book's presence on the market, depending on the number of orders; an avoidance of warehousing costs; and a guaranteed low-cost modification, meaning that authors can much easier publish their work. The reader can buy books at a low cost, find rare texts or batch editions, and personalise the book to his preference.

3.3.3 Resource reduction

Reduction of resources refers to the design for system stakeholders' interactions that reduce the sum of the resources used by all products and services of the system.

Materials and energy, albeit with different intensity for different products, are used throughout the entire life cycle. For that reason the design approach must aim at reducing consumption of resources at all stages, including design and management activities. It is obvious that a reduction in the use of resources determines the avoidance of environmental impact regarding what is no longer used. Using less material diminishes impact, not only because fewer materials are manufactured, but also due to avoiding their conversion, transport and disposal. In the same way, lower energy use diminishes impact, thanks to a smaller amount of energy that has to be produced and transported.

Finally, from a systems perspective we have to consider the overall and interlinked material and energy reduction of the whole of the product assortment or support products needed to satisfy a certain demand related to needs and desires.

An existing system presents problems in qualitative terms related to amounts of resources when:

- The system consumes high quantities of energy
- The system consumes high quantities of natural resources or absorbs high quantities of consumables
- The products, packaging or support products are highly material intensive

PSS example of resource reduction

Cleaning wiper service—MEWA Textil-Management

MEWA's full service provides reusable cotton wipers to industrial companies, printing plants and repair shops. The textile management system enables its customers to return soiled cleaning wipers. It involves delivering, collecting, washing and replacing wipers. At agreed delivery intervals, the service drivers exchange the soiled textiles for clean ones, which are delivered in special safety containers. After being washed at MEWA's state of the art laundries, the wipers are delivered again. Every wiper may go through this cycle up to 50 times. Although cheap throwaway cloths are available on the market, rising disposal costs for heavily soiled single-use cloths make the MEWA service a very attractive option. In fact, MEWA is now the market leader in the cleaning wiper industry in Germany. The company has not only improved its service but also the material cycles involved. The solvents present in the returned wipers are used in the cleaning process. Water is reused several times sequentially through the washing and drying stages, and the oil present in the waste water is recycled and used to generate energy at the MEWA plant. After being treated at the MEWA plant, the waste water is clean enough to be accepted by normal municipal waste water treatment plants.

3.3.4 Waste minimisation/valorisation

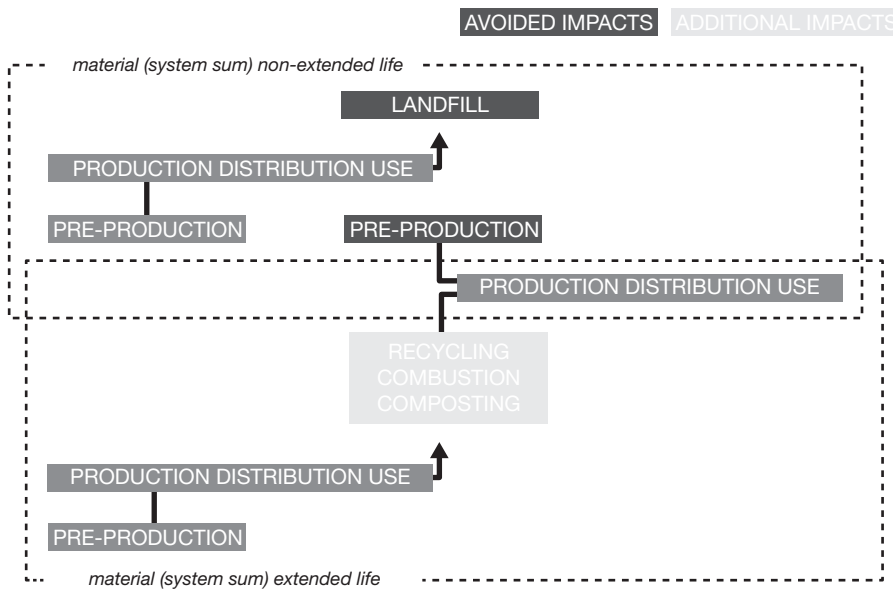
Waste minimisation/valorisation entails the design for system stakeholders' interactions to improve the total amount of the system's recycling, energy recovery and composting and reduce the total amount of the waste produced.

We use the term *recycling* when secondary raw materials are used to manufacture new industrial products and composting when secondary raw materials are made into compost. In addition, waste that can be reintroduced into production cycles at added value, i.e. valorising the waste, can be taken into consideration already early in the design process.

In all these cases the environmental advantage is doubled (see Figure 3.5). First we avoid the environmental impact of disposing of materials in landfills. In the second place resources or energy are made available for production avoiding the impact from the extraction and processing of a corresponding quantity of materials and energy from virgin natural resources. The impact of these avoided processes can be considered as an indirect environmental advantage.

Finally, from a system perspective we have to consider the overall and interlinked (or eventually added) environmental impacts that we can avoid, of all the products or support products needed to satisfy a certain demand.

Figure 3.5 **Environmental advantages of extending the lifespan of materials of all products and support products of a certain system of satisfaction**



A clarification on materials' recyclability must be provided: it is common to hear that a certain material is 100% recyclable. Often these statements have no meaning. In fact, in one way or another nearly all materials are recyclable. Therefore reconcilability obviously depends on the specific material's characteristics, namely the performance's recovery potential and the relative costs: e.g. metals recover their performance better than plastics after recycling.

However the recyclability also depends on the way a material is 'fitted' into a product, if it is easy to separate it from others: we can say that it depends on the

product's architecture. We could have a material capable of well recovering previous performance but very difficult and not convenient to be separated from others. Here they cannot be called recyclable materials.

Similarly recyclability depends on every recycling phase, beginning from collection and transportation. We could have a material capable of recovering its performance, easily separated from others, but much too costly to be collected and transported to the recycling sites, meaning that they are not recyclable materials.

An existing system presents problems in qualitative terms that are related to waste minimisation and valorisation when:

- The products of the system produce high quantities of landfill waste at the end of their service-life
- The packaging and support products produce large quantities of landfill waste

PSS example of waste minimisation/valorisation

Pay Per Page Green—Ricoh

Ricoh offers a package deal (Pay per Page Green) and installs, maintains and collects at the end-of-life the printers and photocopiers (not owned by the customer); the customer pays for the number of delivered pages and copies. The *innovative interaction* between the company and the client provides the company's economic interest to provide (and design) long-lasting, re-usable and recyclable photocopiers.

Components are tested and functional parts are re-manufactured or directly re-used in a new photocopier. Damaged components are directed to material recycling. Ricoh products are designed to allow component compatibility between different models and to facilitate the whole processes of re-using or re-manufacturing.

3.3.5 Conservation/biocompatibility

Conservation and biocompatibility entails the design for system stakeholders' interactions that improves the overall amount of the system's resource conservation or renewability.

An explanation is needed on resource renewability. Timber is a renewable material, but the same type of wood can be procured from two different areas, where one is under planned and controlled exploitation and the other not, leading to deforestation. The very same material can qualify as renewable in the first case and not renewable/non-reproducible in the other case. It can be summarised that renewability depends on specific re-growing speed and extraction frequency. Therefore we can define that:

> a resource is renewable when the consumption rate is smaller than the natural re-growing rate.

Finally, from a systems perspective we have to again consider the overall and interlinked level of renewability of all the materials, products or support products needed to satisfy a certain demand.

An existing system presents problems in qualitative terms related to conservation and biocompatibility when:

- All the energy produced is derived from exhausting resources (e.g. fossil fuels)
- The system uses depleting and/or non-renewable materials for products, support products, packaging, and infrastructure

PSS example of conservation/biocompatibility

Qurrent, the Netherlands

Qurrent's mission is to create an energy-neutral society. Therefore, Qurrent stimulates fair, clean and local energy consumption. It aims to change consumer behaviour. As times are changing, people more and more feel the need to be independent and are open to build decentralised energy communities. Qurrent offers them the opportunity to make their own choice, generate their own energy and use less energy. As a result consumers become independent.
Changing customer behaviour starts with knowing what the actual energy consumption is and what the standard of an average household is. 'Mijn Energie' offers this insight on a daily, weekly, monthly and yearly basis. The Qbox also registers the performance of solar panels. The data is collected via the Qbox.
To enable customers to consume less energy Qurrent also supplies solar panels, insulation and energy saving products such as LED lights. As Qurrent is an advocate of independence, the Qbox is easy to install and works with every energy company.

The benefits of the Qbox:

- Savings of up to 10% on your energy bill
- Easy to install yourself
- Compatible with any energy supplier you have
- Insight into how your solar panels perform
- Comparisons with other households

3.3.6 Toxicity reduction

Reduction of toxic emissions involves the design for system stakeholders' interactions that reduce or avoid the gross total of toxicity and harmfulness among the resources utilised or emitted by the system.

Regarding this criterion it is important to remember that a truly effective approach must always refer to the entire life cycle and to every concurring process of the whole of the products and the support products of a particular system of satisfaction. This means that various technologies for transforming and treating materials (some of them involving toxic or noxious emissions while others, equally effective, might not) have to be considered along with distribution systems that cause the least harm to the environment and products designed to use energy and consumable resources less invasively. Finally, we must orientate our choice of materials (and additives) towards minimising the emissions that occur during disposal.

To illustrate materials' environmental impact, we have to understand that except for toxic materials (such as asbestos, which must be avoided) the environmental impact depends upon both:

- The material-specific characteristics, and
- The product-specific characteristics

Let us take as an example a composite material such as a polymeric matrix filled with fibres. Though it is used to manufacture disposable dishes, it is a bad material in terms of environmental impact, since it causes many problems in the disposal phase and is resource-intensive in production.

On the other hand, the same composite material could have a lower environmental impact if used to produce some parts of a product needing to be transported, having the greater impact in the usage phase due to e.g. fuel consumption. While this material is probably lighter than others, it will, by reducing the overall weight, reduce the whole transportation consumption. Therefore it may also be a good or at least better material in environmental terms.

For this reason alone it would be misleading to propose a scaled environmental impact ranking of different materials.

Finally, from a systems perspective we must consider the overall and interlinked toxicity of all the materials and processes and all the products or support products needed in satisfying the particular demand.

An existing system presents problems in qualitative terms related to toxic and harmful resources when:

- The processed resources are toxic or potentially toxic for the workers
- The processed resources are toxic or potentially toxic during distribution
- The processed resources are toxic or potentially toxic for the user
- The products, support products, packaging or infrastructure are toxic or potentially toxic during after-service treatments

PSS example of toxicity reduction

Chemical distribution: Dow Chemicals

The Safe-tainer System is a closed-loop delivery system that combines the supply of fresh chlorinated solvents—trichloroethylene, perchloroethylene and methylene chloride—and the collection of used solvents with the professional management and disposal of the waste. The Safe-tainer System includes double-skinned containers that protect the solvent and the waste from accidental damage during transport, handling, storage and use of the containers. The container is actually a drum within a steel container that is fitted with special leak-free couplings to prevent spills, leaks or vapour emissions during use. There are two types of containers: Safe-tainer for fresh solvent, designated for the transport of virgin solvent of the same product and grade, ensuring highest product quality; and Safe-tainer for used solvent, designated for the collection of used solvent (waste) out of the cleaning equipment at the end-use customer, preventing any accidental exchange with the container for fresh product. Dow delivers virgin bulk solvent to filling stations, normally located at the distributor's site, where it is stored in tanks and poured into Safe-tainer containers. The distributor delivers the container for fresh solvent together with the one for used solvent to their customer. The customer connects the container to his cleaning

equipment (degreaser or dry cleaning machine) using special connections. The used solvent is pumped into the designated containers, which are collected by the distributor when full. The waste is extracted from the containers, collected and sent to a recycling station for professional management, i.e. recycling of the used solvent and the disposal of the distillation sludge. The recycled material is re-stabilised and returned to the market at a lower cost than virgin solvent. The Dow subsidiary SafeChem Germany manages the delivery, collection and recycling of the chlorinated solvents using the Safe-tainer product in Europe. SafeChem supplements the Safe-tainer system with educational training for its clients on the optimisation of application use for chlorinated solvents as well as correct methods for handling and recycling. It is the management of the Safe-tainer system through SafeChem that is key to the system innovation. The Safe-tainer system was introduced to help meet customers' needs by virtually eliminating emissions to the environment. Due to environmental legislation and the decline in chlorinated solvent use in Germany, Dow Chemicals Germany entered into a joint venture with a recycling firm, RCN, to form the company SafeChem. The Safe-tainer system was specially designed for SafeChem to allow companies that use the chlorinated solvents in metal and surface cleaning lines to handle the solvents safely and to meet both the performance and environmental demands of their operations. With this system, chlorinated solvent users can improve their solvent operations by implementing safer handling of solvents and effective waste management.

3.4 Design criteria for and examples of social equity and cohesion

PSS presents an opportunity to couple eco-efficiency with social equity and cohesion, as we argued earlier in this volume.[7] Nevertheless, not all system innovations are socio-ethically sustainable. Thus it is important to study cases, develop criteria and guidelines as well as methods and tools, and embed them to manage and orient the design process towards socio-ethical solutions.

In response to this, a set of criteria for designers was developed that serves as one starting point towards ensuring socio-ethical sustainability:[8]

1. Improve employment/working conditions (see section 3.4.1 below)
2. Improve equity and justice in relation with stakeholders (3.4.2)
3. Enable responsible/sustainable consumption (3.4.3)
4. Favour/integrate the weak and marginalised (3.4.4)

7 See Part 1, Chapter 2
8 See the SDO toolkit (www.sdo-lens.polimi.it).

5. Improve social cohesion (3.4.5)
6. Empower/valorise local resources (3.4.6)

A set of guidelines developed for each of these criteria is presented in the appendix.

For a given satisfaction system, some criteria (and their related guidelines) have higher relevance than others. Therefore in a decision-making process (i.e. designing) it is important to identify the socio-ethical design priorities by determining the relative relevance and/or *appropriateness* of each criterion for each system type, meaning the most promising stakeholder interactions.[9]

The following sections will present these criteria together with some examples.[10]

3.4.1 Improve employment/working conditions

When speaking about employment/working conditions we mean a system design that promotes and enhances these conditions (within the enterprise but also at suppliers), e.g. job security, health and safety at work, adequate working hours, fair wages, and conditions enhancing the satisfaction, motivation and participation of the employees.

The role of the designer may be marginal in this case: employment and working conditions are issues determined by company goals and requirements. Nevertheless the designer must be aware of relevant issues and active when possible in terms of enhancing, through e.g. various communications means, fair employment and working conditions.

An existing system presents problems related to employment/working conditions in qualitative terms, when:

- There is forced or child labour
- There are problems with occupational health and safety
- There are problems of discrimination in the workplace
- There are problems with work overload or inadequate wages
- There are problems with freedom of association and right to collective negotiation

9 See Part 1, Chapter 4, Section 4.3.1 Sustainability Design-Orienting toolkit (SDO).

10 The collection of cases of the European research project EMUDE, *Emerging User Demands for Sustainable Solutions,* has provided much valuable information.

PSS example of improving employment/working conditions

Sustainability Accountability, SA8000® certification

Social Accountability International has established one of the world's preeminent social standards—the SA8000 Standard for decent work, a tool for implementing international labour standards—that has improved the lives of over a million workers. SA8000 guides employers to consider the importance of each job and to recognise the equal dignity of each person involved in the supply chain, from the worker to the retailer to the consumer. The SA8000 Standard leverages the power of business and consumer to purchase products made from workplaces that enrich, not denigrate, the livelihoods of people.

Benefits for workers, trade unions and NGOs are:

- Enhanced opportunities for organising trade unions and collective bargaining
- A tool to educate workers about core labour rights
- An opportunity to work directly with business on labour rights issues
- A way to generate public awareness of companies committed to assure humane working conditions.

Benefits for business are:

- Enhances company and brand reputation
- Improves employee recruitment, retention and productivity
- Supports better supply chain management and performance.

Benefits for consumers and investors are:

- Clear and credible assurance for ethical purchasing decisions
- Identification of ethically made products and companies committed to ethical sourcing
- Broad coverage of product categories and production geography

3.4.2 Improve equity and justice in relation to stakeholders

Equity and justice in relation to stakeholders refers to design promoting and enhancing fair and just relations (outside the enterprise): within the partnerships, upstream, downstream and in the community where the offer takes place. It includes for example promoting and enhancing fair and just partnerships; equal and just relations with suppliers, subcontractors and sub-suppliers; equal and just relations with clients and/or end-users; equal and just relations affecting the community where the offer takes place; and equity and justice with local institutions/agencies.

An existing system presents problems related to equal and just relations between stakeholders, when:

- There are stakeholders criticising the supply system
- There is a client/final user criticising the supply system
- There are unjust relations between the partnerships
- There are unjust relations with suppliers, subcontractors and sub-suppliers

PSS example of improving equity and justice in relation to stakeholders

CTM Altromercato Consortium, for fair trade

Established in 1988, Altromercato is the main Italian body for fair trade organisations and the second largest worldwide; it is made up of 118 cooperatives and non-profit associations that manage 300 Botteghe Altromercato (World Shops) in Italy. Botteghe Altromercato are locations where fair trade products are offered and information and education is given. Fair trade is based on a 'fair' price paid to the manufacturer and on an equal relation between small groups of democratically organised manufacturers and Altromercato purchase central. Altromercato is registered with the World Fair Trade Organization and today collaborates with 170 organisations in 50 countries, involving local artisans and farmers. The project stands for respecting manufacturer rights and facilitating trade with emerging and low-income countries. Altromercato guarantees equitable prices on products according to real production costs and salaries, promoting continued cooperation in commercial activities, fostering production of organic produce, while promoting projects dedicated to social and environmental development. Altromercato products include handmade products, clothes, food, and cosmetics which can also be found in supermarkets, local shops, bars, herbalists and other services. In 2010 Altromercato launched a new brand

Solidale Italiano Altromercato, dedicated to domestic fair trade. Altromercato will soon open an online shop.

3.4.3 Enable responsible/sustainable consumption

To enable responsible and sustainable consumption entails a design promoting and enhancing responsible and sustainable client or final user choices or behaviour. This can involve for example making transparent and enhancing the social sustainability of all the stakeholders, providing the information and/or learning experiences to educate the client or end-user on responsible/sustainable behaviour, developing offers that enable responsible/sustainable participation of the client or end-user, or involve the client/end-user in the design, decision process, production, implementation, and/or customisation of his/her own product-service system towards responsible/sustainable behaviour.

An existing system presents problems related to responsible and sustainable consumption, when:

- The client/final user is not able to acknowledge clearly and easily the social (un)sustainability along the whole value production chain
- The client/final user is not able to understand responsible/sustainable behaviour by the supply system

PSS example of enabling responsible/sustainable consumption

Solar panel self-building courses by Tattle group

The Tattle group organises courses on solar panel assembling in Italy. At the end of the course, the students can design their own solar plant and ask the Tattle group to order materials. In order to reduce transportation expenses, the group addresses their supplier—the Austrian AEE cooperative warehouse—only when a fair number of orders has been accumulated and delivers them to the users in one supply schedule. During the course a handbook that includes

software for plant design is available, compiled by the same AEE cooperative. These workshops aim to make solar energy technologies more accessible, while reducing the plant cost by up to 50% with the average price of 2,600 euros, and they train self-sufficient users who are in this way able to save on design, building and maintenance and to spread ecological conscience and awareness.

3.4.4 Favour/integrate the weaker and marginalised

When speaking about favouring and integrating the weaker and marginalised, we mean a system design promoting and favouring (in order to integrate) people such as children, the elderly, the differently abled, the unemployed, the illiterate or any other minority or marginalised social group. This can happen for example by involving and improving the conditions for weaker social strata and marginalised persons, involving and facilitating introduction of foreigners into the social context, developing systems to extend access to goods and services to all social strata, developing systems of shared usage and/or exchange of goods and services to increase their accessibility and developing systems which allow easier access to credit (for companies).

An existing system presents problems related to weaker and marginalised groups when:

- The supply system creates obstacles or limits access to people with weaker social status (e.g. children, the elderly, differently abled, etc.)
- The offering system is not accessible to people with lower incomes
- The offering system favours in some way people's marginalisation

PSS example of favouring/integrating the weaker and marginalised

Co-housing for over 55s—Aquarius, Eindhoven housing society

Aquarius is a community of 45 ageing people in the Netherlands who live in separated but nearby houses, helping one other according to their capacities. The community block is made up of 30 private two-storey houses with a garden, plus a large common room with shared kitchen and a large park. The Aquarius association has, among its duties, that of knowing new potential users and of making a first selection. The preference goes to persons between 55 and 65

years old, active and capable of self-help. Living in a community stimulates social relations and activity; it provides inhabitants with a safe feeling, benefiting themselves and their families; and it lightens some of the heavy care burden off the already stressed public sector.

Image courtesy EMUDE—Emerging User Demand for Sustainable Solutions_ EC FP6

3.4.5 Improve social cohesion

Improving social cohesion denotes a design promoting and favouring systems that facilitate social integration: in neighbourhoods, between generations, between genders and between different cultures. This could happen for example by promoting neighbourhood systems of sharing common goods and maintenance, co-housing systems or co-working systems.

An existing system presents problems related to social cohesion, when:

- The offering system is creating or favouring forms of intra-gender, intra-cultural, or intra-generational marginalisation
- The system is creating/favouring forms of discrimination, e.g. sexual, religious, cultural, or gender

PSS example of improving social cohesion

Flat-sharing between pensioners and students—Associazione Auser Como (Association for self-management and solidarity services), Como, Italy

The project conciliates students' needs (affordable lodging near the university) with those of retired persons (socialisation and fellowship, safety, daily housework help), facilitating communication between people of different generations. The programme provides, for a small payment, the possibility to find lodging in homes of pensioners who live in Como (Italy), for students who are not Como residents. The 'Abitare insieme' project has proved to be an important occasion to promote solidarity and civil economic cohabitation. It is also a way to create interpersonal relations between the aged and youths.

3.4.6 Empower/enhance local resources

Empowering/enhancing local resources denotes a design promoting and favouring systems that regenerate and empower local economies. This could happen for example by respecting or enhancing peculiar local cultural characteristics, developing systems to encourage and foster local economies, regenerating or enhancing unused and discarded artefacts, adapting or promoting systems using regenerated local natural resources, and promoting local-based and network-structured enterprises or initiatives.

An existing system presents problems related to local resources, when:

- The current reference system impoverishes local cultural values and identities
- The current system offers only one solution/few variations for all regions and cultures

- The current system has a negative impact on the social well-being of the local community
- The current system is impoverishing local economies
- The system is absorbing local non-renewable resources

PSS example of empowering/enhancing local resources

Organic food delivered to your home: Local food link Van Group

Local Food Van Link, in association with other groups, helps increase local food production in Skye, Scotland, by distributing produce around the local community. Skye and Lochalsh Food Link is a voluntary association of local producers, caterers, retailers and consumers with an interest in promoting fresh, locally produced food. A shared van links the network and distributes local produce all over the island. The group was initiated in April 2000 by a couple of local producers who decided that rather than delivering every product themselves, they would use a van to drive a set route twice a week, picking up the orders from the producer and delivering them to their customers. By doing so, not only could one save on petrol but also ensure the delivery of local produce all over the island, creating a more sustainable community. The solution both ensures the future of local food producers by distributing their goods and promotes important aspects of economic and environmental community life and the health benefits of locally grown fresh produce. The Skye environment is said to produce some of the best quality food in Britain, free from pollution, genetic modification and other harmful substances. The use of one shared vehicle for a group of 40 farmers clearly minimises congestion and pollution. Detrimental environmental impacts of conventional agribusinesses can be avoided through the promotion of small-scale local production that underpins the notion of healthy and communal living on the island. The consumption of fresh and seasonable food reduces the need for energy for cooling and freezing.

Image courtesy EMUDE—Emerging User Demand for Sustainable Solutions_ EC FP6

3.5 PSS design for sustainability in Asia

3.5.1 PSS design for sustainability in China

It is evident that the future sustainable development of China depends on a radical transformation of the current model of development. China has paid heavy costs for its rapid development over the past three decades, and the ecological crisis and social justice issues have become the most obvious problems. An increasing number of people realise that if the economic development pattern with over-reliance on materialised production and consumption continues, China will inevitably encounter a 'glass ceiling' and reach the limit to its growth in future. In sum, the nation is currently confronting a great crisis, and even the term 'Wei ji' (crisis) in the Chinese language is somewhat mystical, meaning 'danger' but implying 'opportunity' as well.

> To deal with crisis, discussion is important, but action is more important than discussion; action is important, while direction is more important than action. The value guiding our action is a matter concerning the rise and fall of the human being (Sheri 2010).

During this transformation, design innovation based on the idea of sustainable development will play an unprecedentedly significant role. How to construct a theory from Chinese traditional culture, while fit for the contemporary Chinese context, and use it to efficiently instruct innovative system design is a key issue in design research and cultivation of life philosophies and wisdom for the next generation.

In China, even the concept of 'sustainable development' itself is a somewhat exotic concept, a kind of reflection and correction of an unsustainable economic development mode for contemporary Western society: fundamentally a way of thinking that is in essence a subject-object dichotomy. The logic behind it is that since humanity has polluted nature, then humans must govern and protect nature again. However, according to the ancient Chinese thinking of 'harmony between human and nature', human and nature is not a relationship of protection and protected: humanity itself is an integral part of nature. Therefore, if humanity and nature form a symbiotic and harmonious unity, humanity will certainly destroy itself if claiming to be the master of nature.

The concept of sustainability in ancient China is a systematic idea that takes the ecological environment as the core and the harmonious development of mankind and nature as the vision. Accordingly, the core concept of traditional Chinese 'design' can be summarised as the objective to respect heaven and cherish resources, take delight in Tao, value harmony, and stop before going too far. Heaven means 'super nature'; respecting heaven means that 'design' should imitate and follow natural law, make full use of resources and minimise unnecessary waste. 'Tao' is a description of the mighty law of nature in ancient China, and it governs

everything on earth. Thus only by understanding and following the Tao can people gain wisdom and truth and reach an ultimate realm of freedom. 'Harmony' emphasises the social nature of human activities, which is the fundamental principle of traditional value and view of happiness of China. 'To stop before going too far' refers to a consumption concept that encourages a content, cheerful and moderate lifestyle, as the Chinese tradition always shuns excessive luxury. A holistic design approach based on this thinking could truly contribute to humanity's well-being and long-term development.

Current Chinese design theories, for example design Matterology,[11] are deeply rooted in traditional Chinese philosophy, seeking to develop a systematic and comprehensive solution—the way (Tao) of planning matters—rather than focusing merely on materialised product design (see also Xin 2010; Xin and Jikun 2011). This coincides with the current concept of sustainable PSS design. Therefore the essence of Design for Sustainability should be to 'reconstruct the knowledge structure and industry chain, so as to integrate resources and innovate mechanisms, and guide human society to a healthy, rational and sustainable way of living and development' (Guangzhong 2009; see also Guangzhong 2006).

The sustainable development of human society, the earth's limited resources, and constraints on any ideal of infinite expansion of 'individuality', all force us to understand profoundly that the evaluation criteria must be 'appropriateness' and 'moderation': in other words, 'enough is enough', as in ancient Chinese philosophy. 'Wei ji' awareness is a prerequisite for any transformation. In order to deal with crisis and achieve transformation, the opportunity for design in China lies in learning from traditional Chinese wisdom.

3.5.2 PSS design for sustainability in Thailand

In Thailand, the Sufficiency Economy Philosophy (SEP) was first developed by His Majesty King Bhumibol Adulyadej in 1974.[12] The SEP was initiated as an approach toward strengthening Thailand's economic foundation, by assuring that the majority of the population has enough to live on as well as offering a way to avoid various imbalances that cause failures or crisis as found in other countries. It is a generic approach implementable in all areas: from daily life to agriculture, from business to state policy. The philosophy establishes that the SE governs everything from motivation to criteria, to behaviour, and to systems, and addresses all issues within a dynamic setting. Thus its implementation should also be extended to the design discipline. However, applying SEP in the design sector is still relatively underdeveloped.

11 See Part 2, Section 4.
12 See also Part 2, Section 4.

Among the various approaches to Design for Sustainability, Product-Service System (PSS) thinking is comparable to the Sufficiency Economy Philosophy's holistic concept—in the sense that both approaches are concerned with preserving the environment; both favour the development of a system as a whole rather than designing a single product or service; and both set priorities on stakeholder interactions. Notably, while preserving the environment is the inevitable objective, social and economic aspects can never be left out.

Unique aspects of DSE

While the approach of Design for a Sufficiency Economy (DSE) has some similarities to existing DfS approaches, there are aspects unique only to DSE. One of these is the role of designers, which is two-fold. First, DSE helps measure users' behaviour to see whether the existing conduct is compliant with the principles of the SEP. Subsequently, once the designers have observed and identified users' needs, these needs are then prioritised based on the SE principles. The design processes, i.e. of the stakeholder interactions and the components supporting the new system, are then carried out. In other words, the first role of Sufficiency Economy designers is to assess 'how sufficiently our users are conducting their lives at present'. The second role is to put themselves in the company's shoes and explore 'how we (as a company or a service provider) provide a set of products, services or systems that encourage our users to conduct their lives sufficiently'. Simultaneously they ask, 'while doing so, how do we conduct our business to achieve a holistic management of our resources while existing harmoniously with nature and within society?' These roles are achievable by using the DSE's methods, tools and guidelines.[13]

Challenges

The SEP approach is 'strategies oriented' and considered as a means, not the end result. Research on DSE explores how the Sufficiency Economy Philosophy complements design thinking and creates outputs that sufficiently satisfy people in more sustainable ways. Thus the DSE methodology aims to steer the designers' mind-set towards system designing that encourages users to conduct their lives in line with the Philosophy, while the tools and worksheets are used to help designers realise the

13 These guidelines were developed by a group of researchers from the Department of Design, Faculty of Architecture at King Mongkut's Institute of Technology Ladkrabang (KMITL) during the LeNS project period. The group was led by the project manager, Assistant Professor Sompit Moi Fusakul, together with colleagues Praoranuj Ann Siridej and Pwinn Rujikietkhumjron. Section 4 in Part 2 of this volume elaborates upon the SEP and DSE.

concept.[14] The methodology has been tested and further developed in academia and research settings, but thus far only to a limited extent in professional practice.

There are several obstacles to the implementation of the SEP in design that have emerged thus far. The most challenging ones are interpretations and misconceptions. The SEP is considered by many to be an abstract theory for a 'way of living', who therefore find themselves unable to comprehend how the philosophy could be applied in the designing of any products or services. Furthermore, it has been misconceived as a philosophy suitable for guiding rural lives and thus not relevant when it comes to designing for urban lifestyles and business sectors. There is also a misconception that when a person adopts the Philosophy in life s/he must return to the most basic lifestyles and former behavioural patterns, such as growing their own rice, cultivating their own cotton, spinning their own yarn and weaving their own cloth. Such a misconception leads to the misunderstanding that the way of sufficient living clashes with the way of life in modernised cultures.

In fact, the SEP stresses the middle path as an overriding principle for appropriate conduct by the populace at all levels. It enforces the conditions wherein people are to possess honesty and integrity, while conducting their lives with perseverance, harmlessness and generosity. The Philosophy entails ways of thinking that encourage the implementer to be reasonable and be moderate in their actions as well as to develop a resilient immunity, one focused on achieving balance, thus ensuring a readiness to cope with fast or extensive changes. This mind-set should be useful to all conducts and applicable not only in design but also in all areas, eras, cultures and circumstances.

The SEP therefore prepares implementers to meet the challenges and changes arising from globalisation while pointing the ways toward recovery (in case of failure), leading to a more resilient and sustainable economy. This attribute is relevant and challenging, especially in the midst of global threats of destabilised economies, cultural turbulence, environmental deterioration, resource depletion, political turmoil, and so on. The DSE approach is a new interpretation on how the Sufficiency Economy can be applied to the design area, placing the realisation of sufficient well-being within reach.

3.5.3 PSS in India: Gandhi's contributions to design thinking

The Indian contribution to PSS thinking emerges from the knowledge innovations of historic, local movements that challenged the industrial regime of the British Empire and the condition of social and economic oppression it gave rise to. As critical responses, these movements were multiplex, which rejected the new mode of capitalist production, introduced into Indian society by the colonial rulers, as unsustainable on the ecological and political plane. For M.K. Gandhi who

14 See Part 1, Chapter 4 for more details on the DSE methodology. Worksheets and instructions are available for download from the LeNS Tools database (www.lens.polimi.it).

spearheaded the peaceful revolt, serving the poorest person's needs and satisfactions through promoting local manufacture was the key to achieving freedom itself. Clothing and feeding a foreign or urban market while going hungry and naked oneself was morally unacceptable to him in a modern society. Khadi—home-grown, hand-spun and hand-woven cotton cloth—became for him the natural focus of the nationalist Swadeshi or Self-Reliance campaign, serving and providing for the Self, while boycotting the production, distribution and consumption of mill cloths that had invaded Indian markets. PSS thinking, not just practice, remained at the heart of the Spinning Wheel revolution (Brown 2010).

The success of the khadi movement as a political programme for change was presupposed on the sustainability of its praxis and not the other way round. The mass protest it raised to British imperialism was simultaneously questioning the entire product design thinking behind industrial manufacture. Khadi's local, systems approach to social change located 'design' and the designing of products not in the research lab but in the community. The need to re-look and redefine the industrial expert or industrial research professional through 'appropriate' and 'intermediate' technology tools, methods and processes, as they came to be known, was its strong intellectual message to the world, especially all non-Western countries encountering modernity (Prasad 2010).

The model of endogenous innovation demonstrated in the khadi movement not only believed in knowledge as common property but in the production of goods through large-scale people's participation. The revival of arts and crafts initiatives, cooperative systems of rural enterprise, participatory technology innovation and community-based resource use, all an integral part of the khadi movement, served as precursors for contemporary PSS thinking. Recent attempts in India to extend Gandhian ideas to propose an alternate science and technology manifesto have PSS ramifications.[15]

The manifesto suggests the need to design science, technology and industrial policies on the triad of justice (including cognitive justice), plurality and sustainability—all stated aims of PSS thinking (Prasad 2010). The important thing to remember is that business or wealth creation was not left out of Gandhi's programme for change.

Khadi clearly was only one of a continuing tradition of several indigenous knowledge systems, which had, under the rubric of 'development', to contend with obsolescence through modern technology adoption in India. Yet, given the new and complex challenge of climate change today and its disastrous implications for the future, it is these very 'obsolete' knowledge systems which might hold the idea and hope for eventual human survival. PSS initiatives conceived in the west can thus look at design afresh through mutual learning and knowledge dialogues with what

15 See www.kicsforum.net/kics/kicsmatters/Knowledge-swaraj-an-Indian-S&T-manifesto.pdf.

these 'defeated' Asian and European systems have to offer. Outlined below are the various strands of PSS thinking encapsulated in the concept of khadi which continue to have significance for design theory today.

The agricultural model

Gandhi's expressed wish to promote khadi cloth, not in competition with British industry but as an enterprise closer to agricultural production, was indicative of its PSS prefiguring. Khadi's link with village society, which not only grew the cotton but also provided the food for the poor person's subsistence and capacity to labour/serve the nation, was for him absolutely central to recovering India's wealth and subsequent economic freedom from British rule. India, it should not be forgotten, was an early market and trade partner with Britain, the first nation to industrialise, and the pioneering capitalist product—textile—became therefore a worthy battleground for khadi's sustainable alternative. By targeting the villagers' needs, satisfactions and capacities, as the genuine measure of khadi's success, Gandhi brought agriculture and rural society into central thinking on Indian industry.

His notion of spinning as Bread Labour was related to this understanding because even though 'productive bodily labour' related most immediately to agriculture, everyone in modern society was not in a position to take it up and one had to make do with alternatives, always keeping in mind, however, their approximation to the ideal. His confessed learning on the subject of Bread Labour from the Russian writer Leo Tolstoy (himself indebted to the peasant writer T.M. Bondaref) and the English economist John Ruskin is significant in the historical context of British–India relations and the slow but inexorable wiping out of agriculture by industrial capitalism in the developed economies of the west (Gandhi 1960a). A life of labour or artisanal work, all differently argued, did not end with the acquisition of a modern education. In a similar light, modern specialist professions could never completely replace the need for bodily effort with their mental or intellectual achievements. The former remained a necessary corollary to a life of service, and indeed helped free it from purely selfish, livelihood concerns. It was in India however, under the leadership of Gandhi, that these provocative, counter-intuitive ideas of modern times achieved spectacular success through helping achieve a non-violent political freedom from British rule.

It was the emphasis on *service* that brought khadi closer to agriculture as a model for sustainable thinking. As early as 1932, Gandhi had asked himself while imprisoned in a British jail:

> What is the kind of *service* that the teeming millions of India most need at the present time, that can be easily understood and appreciated by all, that is easy to perform and will at the same time enable scores of our semi-starved countrymen to live?

The answer he gave himself and the world was khadi, or: 'the *universalising* of the spinning wheel' (1932: 37) (emphasis added).

Stated in contemporary terms, PSS does not deem manufacture and production alone as prime movers of the economy. Its renewed emphasis on service makes it distinct from mainstream industrial design thinking. By emphasising Bread Labour, Gandhi was only pre-figuring Europe's eventual recognition of sustainability as a possibility to be reclaimed from its own agricultural past.

The business idea of trusteeship

Interestingly, Gandhi's discussions on sustainability retained a space for business and the necessity for the creation of wealth in Free India. By arguing that the rich do not truly 'own' their wealth but are only trustees of it, meaning thereby that they have to manage business profits for the benefit of the community, Gandhi kept capital and capitalists central to his programme for political and social change (1960b). Clearly, the fundamental idea behind the concept of trusteeship was about equity and sustainable growth, not simple-minded charity or philanthropy. The challenge of this concept therefore, and the difficulty faced in adopting it, lay in the radical re-arrangement of society it called for.

Inequality and distinction of rank was not restricted to only differences in the quantum of material possessions owned by the rich and the poor but the perceived capacity of the former to live on the services of others without labouring themselves. Giving up wealth in trust was consequently difficult because it entailed the simultaneous giving up of an entire way of life. Gandhi canvassed for a voluntary change in this mind-set when he addressed the rich and exhorted them to accept the obligation of productive, i.e. Bread, labour. Even a millionaire, he argued, could not be completely inactive and routinely induced hunger through exercise, in order to eat. Why, then, should the rich not labour productively for some portion of the day and remove the basic underlying inequity in society by sharing in the life of the vast majority?

> There is a worldwide conflict between capital and labour and the poor envy the rich. If all worked for their bread, distinctions of rank would be obliterated; the rich would still be there but they would deem themselves only trustees of their property and would use it mainly in the public interest (1932: 22).

When viewed from this lens, a trusteeship approach is a precursor of CSR or corporate social responsibility which today in management circles puts emphasis on reconfiguring social and business structures so that people feel both individually empowered and inclined to act in the common interest. Rejected in independent India as idealistic and based on irrational principles of self-sacrifice, trusteeship has today re-emerged as a valid corporate mission, to meet the challenge of a destabilised and valueless economic and financial system that controls us. Put

very simply, trusteeship asks for a change of perspective on what it means to be wealthy or the owner of capital. It does not deny the role of wealth and capital in today's world for building sustainable institutions but changes the focus of surplus wealth or profit to serving the public good, after satisfying one's own needs. The latter, it is argued, is a prerogative of the capitalist and poor farmer alike who must keep a certain proportion of food and cotton grown, for the Self, before selling to others. Without this injunction, clearly, the khadi movement would not have touched the lives of the agricultural, labouring poor and become the mass movement it did.

Historically, even trusteeship, like CSR, did not mean re-distributing goods through welfare and philanthropy but changing the very structures of capitalist business and industry in such a way that they raised the economic value of social consciousness. A typical recent example is the fair trade movement to which many advanced economies are signatory. Equally, the power of trusteeship is evident in the Global Compact of 2000,[16] introduced by Kofi Annan who helped establish it as Secretary-General of the UN. This argued for businesses to move beyond profit as a measure of value, to metrics that take non-financial aspects into account—putting a new onus on the ability of economists and policy planners to manage and measure progress. As Gandhi had earlier similarly argued, 'True economics stands for social justice, it promotes the good of all equally, including the weakest, and is indispensable for a decent life.'

If equitable distribution of wealth was the measure of an economy's success, rather than the current standard which encourages high income disparities, trusteeship builds a case for CSR being embedded within the very business values of the private sector, wherein distribution of wealth is not about charity but about sustainability. By ensuring basic human dignity, businesses no longer see themselves as distinct from society, nor as serving the interests of production and distribution alone. Even innovation is to be viewed as a social process and user-driven (von Hippel 2005).

With the tempering of capitalist self-interest with social consciousness or responsibility as it is known today, the business idea of trusteeship becomes integrally linked to service provision and not goods accumulation—fundamental tenets of PSS thinking. Inherent too in the trusteeship philosophy are PSS solutions to many of the challenges of the 21st century (Rana 2010):

1. Consuming only what is enough for one's needs without ignoring the needs of others
2. Viewing natural resources as a trustee, where what has been freely provided by nature is taken care of for future generations

16 www.unglobalcompact.org

3. Equitable distribution of goods and services, so people who work for industry and society at large are taken care of
4. Achieving human dignity and growth through satisfaction and well-being, not capital accumulation

The Hindu theory of Varnashrama

Finally, Gandhi's interventions in the industrialism of modern life sought to clarify the theoretical principles underlying the concept of Varnashrama in Hinduism, as a reminder of the socially embedded nature of the economy (Granovetter 1985). He was strongly against the caste customs that engendered 'execrescences' like untouchability, based on the permanent divide between mental and physical or bodily services. But Varnashrama, as a model, held out truths that for him were ecologically, morally and socially sustainable (Gandhi 2009).

Sociologists and environmentalists today are beginning to see Hinduism's caste rules not as rigid monopolies on one's own family work traditions and taboos on others but as a system of self-imposed restraints, which over time curtailed natural and human resource-use and helped conserve regional eco-systems. Madhav Gadgil, for instance, has documented systems of ecological 'prudence' among different groups of people. An ecologically prudent community exercises restraint in the exploitation of natural resources such that the yields realised from any resource are substantially increased in the long run even though restraint implies forgoing some benefit at the present (1985a: 190).

Serving local society and one's neighbours first in the area of one's competence, without robbing the others' livelihood, was at the heart of the Swadeshi or Self Sufficiency principle which provided khadi with its overarching framework. The protection it offered to the poor in the past is evident from the converse that prevails today. Menial labour or service such as washing clothes, waste managing, scavenging, hair cutting, personal grooming and the like, has been taken over by the urban educated, through processes of occupational diversification, leaving large swathes of the illiterate population jobless. Indeed, even skilled, high-value traditional occupations such as the healer/doctor, the architect/carpenter and creative artiste have been usurped by members of the upper castes, educated in English-language based university disciplines. Earlier de-barred from taking up these areas of work because of their association with the bodily, material base of human life, upper castes are today the elite service professionals of modern India.

The poor and the lowly have lost out twice over in the modern economy. Earlier, as Leach demonstrated *at the systemic level*, the socio-logic of caste inverted the privileged class hierarchy authorised historically in the west (Leach 1960). Unlike European feudalism, which was based on a pyramid of wealth status and power with the aristocracy—the minority—at the top, the Hindu varna system gave power to the lowest rung by providing the masses a monopoly over services, which no one

else could or would perform *as livelihood*, in the public domain. This village culture of socially embedded economic transactions also curtailed material and technology use to a much lower level than was current in consumerist, DIY cultures.

Mont and Plepys have convincingly argued against the proliferation of power tools which are seen by middle-class westerners as an essential part of a household's garage or workshed equipment. They are rarely used (2004). Design obsolescence on the industrial plane is the overt partner of this 'hidden' disuse. Many products are produced to be discarded in design labs even before they are used. Today, the time that products disappear from the shelves to be replaced by new ones is steadily decreasing. The rate of obsolescence of products, in other words, is steadily growing, with disastrous consequences for the limited resources of the world.

Hindu caste society, predominantly developed in a village-based economy, was autonomous enough to have been stereotyped as a 'little republic' by the British administrators (Baden-Powell, 1957). The villagers' daily and ceremonial needs were met by households, whose services were pooled and shared by all. The technologies and tools of the trade consequently did not proliferate but remained concentrated in the hands of the servicing households. The civilisational value of material possessions, which negotiate the body's exchange with nature, did not therefore need to be optimised because satisfaction could be achieved without any personal, product-based intervention. Eating on a banana leaf, sleeping on a straw mat, the absence of cutlery and crockery and the wearing of unstitched garments were in any case local, daily practices which not only presumed but produced a culture of an enormously lowered resource and technology consumption.

In a celebrated essay (1958), Charles and Ray Eames, the design thinkers who provided the moving force behind the setting up of the National Institute of Design (NID) in Ahmedabad after Indian independence, identified this culture of minimalism in the *lota*, a vessel with tremendous material variety and potential for multipurpose use. The ease of transporting, storing and dispensing of water for ritual, culinary and ablutionary needs in the *lota* made it score high on the axes of material conservation, economy, utility and beauty. These design traditions, they argued, should be supported in modern Indian training against earlier approaches, which westernisation and English education had introduced in Indian society, whereby having and using objects became a sign of social, even spiritual, advancement.

Giving evidence of this imported mind-set, C.W. Leadbeater, the Theosophist who 'discovered' the philosopher J. Krishnamurthy as a boy on the beach, swimming with his brother, wrote to Annie Besant, a fellow Theosophist and Congress worker in India that he had received instruction from on high to take on the boys:

> They have lived long in Hell; try to show them something of Paradise… Teach them to use spoons and forks, nail brushes and tooth brushes, to sit at ease upon chairs instead of crouching on the ground, to sleep rationally on a bed, not in a corner like a dog (Jenkins 2000: 84).

This training, instilling a comfort level in the boys with the material requirements of everyday life in the west, was to be given prior to Krishnamurthy's presentation to the world as the Messiah. The contrast with Gandhi's understanding of self-advancement is more than evident from his adopted 'half-nakedness' the moment he returned to India from South Africa and took up public service as a vocation.

The point being made here is that in a culture where product exchange is inextricably linked to service exchange through persons and their interpersonal, intergroup activity, not the direct market, the proliferation of things is bound to decrease. Gandhi tried to remind us of the principles that lay behind these ways of life which had been changed forever by capitalist colonial rule. PSS thinking is doing very much the same to bring about sustainability today.

4

Methods and tools for system design for sustainability

4.1 Criteria, methods and tools

Before introducing and describing methods and tools, let us summarise the main issues understood so far. It has been argued that a potential role exists for *design for sustainability*, in promoting and facilitating *system innovation* resulting in environmentally beneficial, economically viable, and socially equitable/cohesive enterprises/initiatives offering a mix of products and services, especially when based on a network-structured and locally based model.

A first key point is the approach to the design of the stakeholders' configuration, committed to creating and promoting innovative types of interactions and partnerships between appropriate socio-economic stakeholders of a system responding to a particular social demand. Consequently new skills are required from the designer:

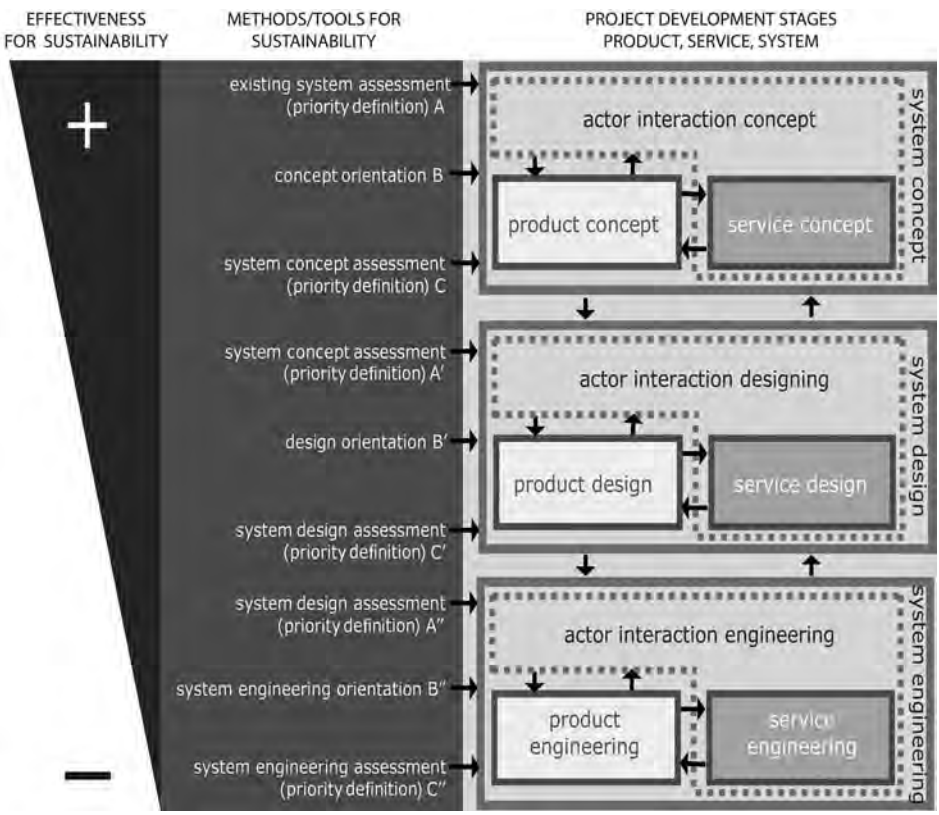
- A designer must be able to design together products *and* services, related to a given demand (needs and/or desires), i.e. a *satisfaction unit*
- A designer must be able to find, promote and facilitate innovative configurations (i.e. interactions/partnership) between different *stakeholders* (entrepreneurs, users, NGOs, institutions, etc.), i.e. a satisfaction system related to a given demand (needs and/or desires) as a *satisfaction unit*
- A designer must be able to operate/facilitate a participatory design process among entrepreneurs, users, NGOs, institutions, etc., orientating this process towards sustainable solutions

A second key point, given that not all system innovations will have eco-efficient or socially equitable and cohesive results, underlines that the design process should always be oriented towards sustainable solutions. Consequently these new skills are also required from the designer:

- The ability to orientate the system design process towards *eco-efficient* solutions[1]
- The ability to orientate the system design process towards *socio-efficient* solutions[2]

In order to learn how to use methods and tools to orientate design towards sustainable solutions it is useful to use as a benchmark a simplified scheme of the development phases of products, services or systems, where those phases can be underlined that lead to design of the system concept, then to detailed design of the system, and finally lead to the related system engineering.

Figure 4.1 **General action plan for the designing process of a product-service system, where sustainability-orienting tools can be integrated into the various stages of the design process**



In the case of system development the configuration of actors in this system, or rather the design of their interactions, should be defined during the conceptual phase. Obviously integrating the necessary requisites for a sustainable outcome,

1 Encompassing both environmental and economic sustainability.
2 Encompassing both socio-ethical and economic sustainability.

i.e. appropriate methods and tools, during the first phases of the development is more efficient. In this chapter we will describe a series of tools that have been developed that can be applied during different phases of development. Besides the singularities, more generally they are meant to assist the designer to accomplish three specific objectives:

1. Setting the sustainability priority (existing system assessment)
2. Generating a sustainability-focused idea (innovative system development)
3. Checking/visualising the sustainability improvement/worsening of developed concept/s (comparing the existing and innovative system)

Various research projects have been funded by the European Union and one by the United Nations Environment Programme (UNEP)[3] over the past few years with the aim of developing and testing methods and tools for system design, the main ones being SusHouse,[4] ProSecCo,[5] HiCS,[6] MEPSS,[7] and SusProNet.[8]

In this chapter the *Methodology for System Design for Sustainability* (MSDS) is described, together with its tools for system design for sustainability. This is one of the results of the LeNS project, integrating and updating what was produced in those projects together with other tools linked to other approaches to system design for sustainability (such as designing for the Sufficiency Economy Philosophy). Both methodology and tools have been tested during a set of pilot courses as part of the LeNS project as well as in several company consultancies. The latter includes *Less waste: other ways of doing things*, commissioned by ASM Brescia to draw up scenarios and system concepts for the prevention at source of trash production in food and paper chains,[9] another project commissioned by KONE (elevator) to develop eco-efficient system concepts,[10] and a further project with the same aim commissioned by Tetra Pak (food packaging).

It is important to stress that experimentation both in applied research projects and in teaching (LeNS) has been fundamental and will continue to be so in future in order to allow methods and tools to be assessed, honed and improved.

3 Design for Sustainability (D4S): A Step-By-Step Approach (UNEP funded, 2005–2009) (see Tischner and Vezzoli 2009).
4 SusHouse: Strategies towards the Sustainable Household (EU funded, 1998–2000) (see Vergragt 2002).
5 ProSecCo: Product-Service Co-design (EU funded, 2002–2004).
6 HiCS: Highly Customerised Solutions (EU funded, 2001–2004) (see Manzini, Collina and Evans 2004).
7 MEPSS: MEthodology for Product Service System development (EU funded, 2002–2005) (see Van Halen, Vezzoli and Wimmer 2005).
8 SusProNet: Sustainable Product-Service co-design Network (EU funded, 2002–2005) (see Tukker and Tischner 2006).
9 For further information on how the method was implemented in the project see Ceschin and Vezzoli (2007) and Vezzoli and Ceschin (2009).
10 See Cortesi, Vezzoli and Donghi (2010).

4.2 MSDS: a modular method for system design for sustainability

The MSDS method aims to support and orient the entire process of system innovation development towards sustainability. It was conceived for designers and companies but is also appropriate for public institutions and NGOs. It can be used by an individual designer or by a wider design team. In all cases special attention has been paid to facilitating co-designing processes both within the organisation itself (between people from different disciplinary backgrounds) and outside, bringing different socio-economic actors and end-users into play.

The method is organised in **stages**, **processes** and **sub-processes**. It is characterised by a flexible **modular structure** so that it can easily be adapted to the specific needs of designers /companies and to diverse design contexts and conditions. Its modular structure is of particular interest in the:

- *Procedural stages:* all the stages can be used or certain stages can be selected according to the particular requirements of the project
- *Tools to use:* the method is accompanied by a series of tools (many of them elaborated within the above-mentioned European and UNEP research projects). It is possible to select which of these to use during the designing process
- *Dimensions of sustainability:* the method takes into consideration the three dimensions of sustainability (environmental, socio-ethical and economic). It is possible to choose which dimension to operate on
- *Integration of other tools and activities:* the method is structured in such a way as to allow the integration of design tools that have not been specifically developed for it. It is also possible to modify existing activities or add new ones according to the particular requirements of the design project

The basic structure of MSDS consists of four main stages:

- Strategic analysis
- Exploring opportunities
- Designing system concepts
- Designing (and engineering) a system

A further stage can be added, across the others, of drawing up documents to report on the sustainability characteristics of the solution designed:

- Communication

The following table shows the aim and processes for each stage.

Table 4.1 **The stages of MSDS with their relative aims and processes. Sustainability-oriented processes are in bold; Design for a Sufficiency Economy processes are in bold italic**

MSDS method		
Stage	**Aim**	**Processes**
Strategic analysis	To obtain the information necessary to facilitate the generation of sustainable system innovation ideas	Analyse project proposers and outline the intervention context Analyse the context of reference Analyse the carrying structure of the system **Analyse cases of sustainable best practice** **Analyse sustainability of existing system and determine priorities for the design intervention in view of sustainability** ***Sufficiency need assessment***
Exploring opportunities	To make a 'catalogue' of promising strategic possibilities available or, in other words, a sustainability design-orienting scenario and/or a set of sustainably promising system ideas	**Generating sustainability-oriented ideas** ***Sufficiency opportunity exploration*** Outline a design-oriented sustainability scenario
Designing system concepts	To determine one or more system concepts oriented towards sustainability	Select clusters and single ideas Develop system concepts **Environmental, socio-ethical and economic assessment** ***Sufficiency system design***
Designing (and engineering) system details	To develop the most promising system concept into the detailed version necessary for its implementation	Detailed system design Sufficiency development of system implementation **Environmental, socio-ethical and economic assessment** ***Sufficiency design evaluation***
Communication	To draw up reports to communicate the general and above all sustainable characteristics of the system designed	Draw up the documentation for communications of sustainability ***Sufficiency design communication***

The following sections present each stage describing its component processes. Particular attention has been paid to sustainability-orienting processes.

4.2.1 Strategic analysis

The aim of the first part of the method is to collect and process all the background information necessary to the generation of a set of potentially sustainable ideas. The objective is two-fold: on the one hand to understand the existing situation and find out more about the project proposers, the socio-economic context in which they operate and the dynamics (socio-economic, technological and cultural macro-trends) that influence that context; on the other hand, to process information by which to steer the designing process towards the generation of promising solutions. The processes are outlined below.

Defining the context of intervention and analysing the project proposers

Given that the project proposers may be companies, public institutions, NGOs, research centres, or a mix of these, the *aim* of this activity is first and foremost to define the scope of the design intervention, or rather the demand for well-being to be met (e.g. move around the city comfortably and conveniently or have clean clothes). At this point the characteristics of the project proposers are examined carefully: their 'mission', their main areas of expertise, their strength and weaknesses, opportunities and threats, in relation to the area of intervention. In addition, particularly if the proposer is a company, the value chain will be analysed to understand how this is structured, what actors come into play, what problems (environmental, socio-ethic and economic) may be met.

Key questions:

- What is the demand to be met?
- What are the key areas of expertise of the project promoters?
- What are their main strengths and weaknesses?
- Who are the main actors? What is the relationship between/among them?
- What are the main environmental, socio-ethical and economic problems associated with the value chain?
- What is the value for the client and/or end user?

Analysing the context of reference

The *aim* of this activity is to analyse the context, or rather the socio-technical regime, of which the new innovation will become a part. First of all, the structure of the production and consumption system (the scope of intervention) is analysed: what actors come into play (companies, institutions, NGOs, consumers etc.) and

what the relationships are between them, as well as what specific dynamics (technological, cultural, economic and regulatory) characterise the system itself. Special attention is also paid to current and potential competitors (analysing their characteristics and offers) and to clients and/or end users (analysing their needs).

Key questions:

- How is the entire production and consumption chain structured in relation to the scope of intervention (satisfaction unit)? Who are the main actors (public and private) and their respective interests?
- What are the technological, cultural and regulatory dynamics influencing, or of potential influence to, the characteristics of the production and consumption chain?
- Who are the main competitors? What are their offers and how do these differ from those of the project proposers?
- Who are the potential clients and end users? What are their needs? Are their needs satisfied?

Analysing the carrying structure of the system

The *aim* of this activity is to identify and analyse the general macro-trends (social, economic and technological) that lie behind the reference context. It is important to understand these in order to understand what potentially influences the context (or socio-technical regime) that will be the object of the intervention.

Key question:

- What are the main social, economic and technological macro-trends? How may these influence the reference context and consequently the design options?

Analysing cases of excellence for sustainability (best practices)

The *aim* of this activity is to analyse in detail cases of excellence (not necessarily concerning the area of intervention) that could act as a stimulus during the generation of ideas. The *result* will be a document summarising the offer in each case of excellence, interactions with the user, the offer producers and providers, and its sustainability characteristics. The supporting *tools* include the *SDO toolkit* for analysing sustainability characteristics, the *System Map* and the *Interaction table* for the general case description.

Key questions:

- What is the offer, in terms of products and services? How does the user interact with the offer?
- Who are the actors in the offer system? What are their intentions?
- What are the environmental, socio-ethical and economic advantages?

Analyse sustainability of existing system and determine priorities for the design intervention in view of sustainability

The *aim* of this activity is to analyse the existing context from an environmental, socio-ethical and economic point of view in order to identify the design priorities (in other words, where it is most important to intervene in order to reduce the environmental, socio-ethical and economic impact to the greatest degree). This operation is fundamental to steering the design process towards the solutions that are the most able to foster sustainability. The *result* will be a document summarising the environmental, socio-ethical and economic analysis and defining design priorities. One supporting *tool* for this process is the *SDO toolkit* (section Checklist, Existing system).

Key questions:

- What is the situation in the existing context regarding environmental, socio-ethical and economic sustainability?
- What are the design priorities for each dimension of sustainability?

Sufficiency need assessment

The *aim* of this activity is to thoroughly assess the existing situation with respect to the Sufficiency Economy Philosophy (SEP)'s three components: Reasonableness, Moderation and Self-Immunity. It is the first stage in the Design for a Sufficiency Economy (DSE) approach: planning/design and implementation processes aimed at achieving sufficient living and sustainable well-being for individuals, communities and societies.[11] The assessment should yield robust knowledge on the current situation: who the stakeholders are within the system; their behaviours and interactions; and how the existing system operates. It is also essential to detect any recent changes that may lead to a particular future trend. The most crucial task is to assess whether the conducts (both of users and product/service providers) in the existing situation are aligned with the principles of the SEP. The *result* will be a document that clarifies the current sufficiency level and illustrates if the existing system displays a balance (or imbalance) in the four dimensions of People, Planet, Profit and Technology, an imbalance implying weak aspects that need to be addressed. *Tools* for this step include task analysis, DSE Checklists (Part 1), and Evaluation of the Sufficiency Levels (Part 2).

11 For more on the Sufficiency Economy Philosophy and DSE, see Part 1, Section 3.5.2, and Part 2, Section 4.

Table 4.2 **Strategic analysis: processes, sub-processes, results and tools. System design tools for sustainability described in detail in the following sections are shown in bold**

	Process	Sub-process	Results	Tools
Strategic analysis	Project promoter analysis and definition of intervention context	Defining scope of design intervention	Document specifying scope of intervention and design brief	
		Project promoter analysis	Summary of project promoter analysis: *Mission* *Main expertise* *SWOT* *Value chain* *(actors, structure, etc.)*	Preparatory company questionnaire[12] **miniDOC** SWOT matrix[13] **System Map**[14]
	Reference context analysis	Production and consumption system analysis for the scope of design intervention	Summary of production and consumption system analysis for the scope of intervention: *Identification of actors and their interactions* *Identification of technological, cultural and regulatory dynamics*	**System Map** **miniDOC**
		Competitor analysis	Summary of competitor analysis: *who are the competitors and what are the most innovative offers; how is the market segmented competitive position analysis*	Model 5 Porter forces
		Client and/or end user analysis	Summary of client/end user needs: *Analysis of expressed and latent needs*	Exploring Customer Needs[15] **miniDOC**

12 Created during the MEPSS research project (www.mepss.nl/index.php?p=tool&l4=W02).
13 For an example of a SWOT analysis, see the tool packet created during the MEPSS project (www.mepss.nl/index.php?p=tool&l4=W05).
14 A tool similar in purpose to the *System map* is the *Actor network map*. For further information see Morelli (2006a).
15 Created during the MEPSS project (www.mepss.nl/index.php?p=tool&l4=W17).

	Process	Sub-process	Results	Tools
Strategic analysis	System carrying structure analysis	General macro-trend analysis	Report on (social, economic and technological) macro-trends and their influence on the reference context	
	Analysis of cases of excellence for sustainability	Identification and analysis of cases of excellence	Summary of cases of excellence analysis, describing: *Offer composition and interaction with the user* *Actors who produce and deliver the offer* *Sustainability characteristics*	**Interaction table (storyboard)**[16] **Animatic** **System Map** **Sustainability Design-Orienting (SDO) toolkit**[17]**—*checklist best practice***
	Analyse sustainability and determine priorities for the design intervention in view of sustainability	Existing context analysis from an environmental, socio-ethical and economic point of view	Summary of the existing system analysis	**SDO toolkit—*checklist existing system***
		Defining the design priorities	Definition of the design priorities for each dimension of sustainability	**SDO toolkit—*checklist existing system***
	Sufficiency need assessment	Observing users and conducting task analysis	Summary of user behaviour and how the existing system operates	DSE Worksheet 1: User observation Task analysis flow chart
		Defining the material products/ immaterial services, actors and flows in the existing system	List of products/services and actors (stakeholders) in the existing system	DSE Worksheet 2

16 A tool similar in purpose to the *Interaction table* is the Use cases. For further information see Morelli (2006b).

17 Another tool that can be used to analyse the sustainability characteristics of a Product-Service System is the INES, Improving New Services, tool created during the 'Eco-efficient PSS' research project, funded by the Austrian Ministry of Transport, Innovation and Technology.

	Process	Sub-process	Results	Tools
Strategic analysis		Mapping the current stakeholder interaction	System maps that illustrate the stakeholder relationships in the current system	DSE Worksheet 3 (System Map)
		Detecting key changes/drivers related to the existing situation	Summary of future trends related to the existing situation	DSE Worksheet 4 (PESTE Analysis)
		Assessing whether existing conducts are in line with the principles of the SEP Assessing the current Sufficiency level	Summary of the Sufficiency Level of the existing situation on a scale of 0–6	**DSE Worksheet 5:** ***Part 1 Checklists Part 2 Sufficiency level***
		Assessing the 'BALANCE' of the existing situation	Visualised Sufficiency Level 'balance' of the existing situation *regarding both the 4 dimensions (People, Planet, Profit and Technology) and the 3 components within each dimension (Reasonableness, Moderation and Self-Immunity)*	**DSE Worksheet 13:** ***Sufficiency Economy Balance Tool***

4.2.2 Exploring opportunities

The aim of the second stage is to identify possible orientations for the development of promising systems. This takes place through a participatory process whereby the various actors generate ideas.

It must be stressed that the aim of this idea-generating process is not to come up with incremental improvements at product or service level, but rather to come up with possible innovations at system level, characterised by radical improvements from an environmental, socio-ethical and economic point of view. At the same time, Design for a Sufficiency Economy qualifies this by encouraging *step by step* development, where 'radical' innovations or changes are welcome only when 'appropriate'. To achieve this, an application of knowledge with due consideration and prudence is essential.

The specific aim is therefore to use all the information collected and processed during the previous stage to outline a 'catalogue' of promising strategic possibilities, in other words a *sustainability design-orienting scenario (SDOS)*, consisting of sustainability-oriented *visions* and *innovative ideas*. This scenario, with its visions

and ideas, constitutes the basis for the future development and implementation of sustainable system innovations. Three exploring opportunities processes are outlined below.

Generating sustainability-oriented ideas

On the basis of the information previously acquired, a set of potentially sustainable ideas is generated through an idea-generating workshop. The starting point is the definition of the satisfaction unit to be met by designing. It must be made absolutely clear that the idea generation must be orientated towards satisfying a specific demand for well-being (e.g. clean clothes). In this sense particular attention is paid to coming up with system level ideas, i.e. ideas regarding: 1) the products and services that constitute the offer; and 2) the configuration of actors able to produce/deliver that offer. Special design guidelines have been drawn up to steer idea generation towards sustainable system solutions (e.g. the idea-generating tables from the Sustainability Design-Orienting toolkit software). It is also useful to have a collection of cases of excellence available as a further stimulus, and a map of the actors who may potentially become part of the satisfaction system.[18] The *result* of this process will be a document listing the satisfaction unit and subsidiary satisfactions and a set of system ideas with their environmental, socio-ethical and economic sustainability characteristics.

Key questions:

- What is the satisfaction unit to be met by design?
- Who are the actors who may potentially be involved in the satisfaction system?
- What potential product and service systems are capable of bringing radical improvements (from an environmental, socio-ethical and economic point of view)? What actor system will be able to produce and deliver such an offer?

Drawing up sustainability design-orienting scenarios (with their visions and clusters of ideas)

The aim of this process is to map out the ideas generated previously, using a purpose designed polarities diagram.[19] This diagram, together with the mapped ideas, constitutes what it is known as a sustainability design-orienting scenario, i.e. a set of visions of how a context could evolve if certain dynamics (economic, regulatory

18 This tool is called a *Satisfaction system map*; for a more detailed description see Section 4.3.7—Satisfaction system map.

19 See description of the tool in Section 4.3.10—Polarities diagram. Here it suffices to say that it is a diagram with two polarity axes (e.g. user participation: enabling offer vs. full-service offer; system organisation: centralised system vs. distributed system), on which it is possible to position and organise ideas.

and socio-cultural) took place and if certain design options were adopted. Therefore the scenario outlines a set of visions, or better, possible promising design orientations. Every vision in turn is described by a set of single ideas and clusters (sets of ideas with basic elements in common). These visions, single ideas and clusters, constitute the basis for discussion by which to identify the most promising directions in which to orientate system innovation.

Sufficiency opportunity exploration

The aim of this stage in the DSE process is to enable designers to define the strengths, weaknesses, opportunities and threats (SWOTs) of the company or system provider, as well as to identify the drivers, goals and objectives of the project. After exploring the competences of the project, the DSE guidelines (Worksheet 8) and SWOT Search Field Matrix techniques (Crul and Diehl 2006: 36-37) are used to generate ideas in the four dimensions: People, Planet, Profit and Technology.

Table 4.3 **Exploring opportunities: processes, sub-processes, results and tools. System design tools for sustainability described in detail in the following sections are shown in bold**

	Processes	Sub-processes	Results	Tools
Exploring opportunities	**Generating sustainability-oriented ideas**	Defining satisfaction unit	Document specifying satisfaction unit and sub-satisfactions	
		Workshop for generating sustainable system ideas	Sets of system ideas with environmental, socio-ethical and economic sustainability characteristics	Stimulus tools for generating ideas: **SDO toolkit—sustainability idea tables** **Satisfaction system map** PSS innovation matrix
	Outline a design-oriented sustainability scenario	Defining clusters and single ideas, identifying promising polarity diagrams, polarising ideas and defining visions	Polarity diagram with polarised ideas. Polarity diagram with visions. Polarity diagram with clusters of ideas. Description of single clusters and single ideas. Audiovisual documents that can visualise concepts and sequences and promote collective conversations	**Polarity diagram** **Offering diagram** **Animatic,** **System concept** **Audiovisual**

	Processes	Sub-processes	Results	Tools
Exploring opportunities	***Sufficiency opportunity exploration***	Identification of the strengths and weaknesses that exist now and future opportunities and threats Analysis of company SWOT in relation to Sufficiency Economy principles	SWOT analysis SEP-relevant SWOT analysis	DSE Worksheet 6 (SWOT matrix) DSE Worksheet 9 (SWOT analysis relating to Sufficiency Economy)
		Identifying company drivers, design goals and objectives	Document identifying design drivers Document defining goal and objective of design (as a company or a system provider)	DSE Worksheet 7 (Company's Drivers and Goal and Objective)
		Generating knowledge and morality-oriented system ideas	List of knowledge and morality promising ideas	**DSE Worksheet 8 (Guidelines: knowledge and morality)**
		Generating Sufficiency promising system ideas	Document of ideas and sketches generated	DSE Worksheet 10 (Search Field Matrix)
		Visualising Sufficiency promising system ideas		DSE Worksheet 11 (Sketch exploration for new Sufficiency PSS)

4.2.3 Designing system concepts

Starting with the scenario (with its visions, clusters of ideas and single ideas) elaborated previously, the aim of this stage is to select the most promising clusters and single ideas through a participatory process whereby actors involved are called to express their opinions. The clusters and single ideas selected are sorted into various groups, each one representing a system concept in an embryonic form. These groups of ideas are then developed in greater detail, defining the set of products and services that make up the offer, together with the actor system that produces and delivers it, and the potential environmental, socio-ethical and economic improvements it offers are assessed. Processes for designing system concepts are discussed below.

Selecting clusters of ideas and/or single ideas

The most promising ideas are selected and combined through a participatory process, possibly supported by purposefully designed tools (see Table 4.4). Each of these combinations will then be developed into a system concept.

Key questions:

- Which ideas are the most promising from an economic point of view and in terms of technological feasibility and user acceptability?
- Which ideas are most promising from an environmental and socio-ethical point of view?

Developing system concepts

One or more system concepts will emerge from the combinations of ideas previously singled out. The following elements are then defined for each of these system concepts: the set of products and services that make up the offer and the functions it fulfils; the actor system (primary and secondary) that produces and delivers the offer; and the interaction between user/client and the offer system. Various tools may be used in support of the designing and visualisation of these elements (see Table 4.4).

Key questions:

- What products and services make up the offer? What functions does it fulfil? What is the value perceived by the user? How does the client/end-user interact with the offer system?
- How is the socio-economic actor system (and their interactions) structured in producing and providing the offer? Which are the principal and which the secondary actors?

Sufficiency system design

The aim of this DSE stage is to refine the ideas generated in the Opportunity Exploration stage while retaining a systemic, holistic, people- and nature-centred approach. The ideas generated in the previous phase are visualised using basic sketching techniques. Relevant ideas are combined in order to construct concepts for the new Sufficiency PSS. Various tools may be used to support the designing and visualisation of the system elements.

Table 4.4 **Designing design concepts: processes, sub-processes, results and tools. System design tools for sustainability described in detail in the following sections are shown in bold**

	Processes	Sub-processes	Results	Tools
Designing system concepts	Selecting clusters and single ideas	Selecting the most promising ideas and/or clusters (from the point of view of economics, technological feasibility and user-acceptability	Polarity diagram with the ideas and clusters of ideas selected Document explaining the selection	**Polarities diagram** Portfolio diagram, Go/no go evaluation criteria[20]
	Developing system concepts	Defining the interactions between actors and the new system	Map of actors in the new system and their interactions (material, information and money flows	**System Map**
		Defining the product and service concepts[21] that make up the offer	Images + texts summarising the main functions delivered to the user	**Offering diagram** AD poster
		Narration of user interactions with the system and the interactions of the other actors in delivering the offer	Sequence (images+texts) of the interactions that occur during the production and delivery of the offer Audiovisual documents that can visualise alternative points of view Audiovisual documents that can visualise action sequences	**Interaction table** **Interaction storyboard** **Animatic, System concept Audiovisual**

20 Tool developed during the European research project SusProNet (2002–2005, 5th Framework Programme).

21 For an example of product concept generation see the MPDS method and its specific tools described in Vezzoli, Ceschin and Cortesi (2009a) *Metodi e strumenti per il Life Cycle Design*.

	Processes	Sub-processes	Results	Tools
Designing system concepts	***Sufficiency system design***	Creating concepts by selecting the relevant ideas and combining them into themes. Selecting the most promising theme and further developing it using tools relevant to system design (e.g. System Map)	Sketches of ideas for new Sufficiency PSS (SE-PSS) System maps, etc.	DSE Worksheet 11 (Sketch exploration for new Sufficiency PSS developed further from previous stage) **System Map** (as above)
	Environmental, socio-ethical and economic assessment	Environmental, socio-ethical and economic improvement potential assessment for the system concept	Description of the improvement potential for every criterion of each dimension	**SDO toolkit—checklist concept**
		Visualising the environmental, socio-ethical and economic improvements	Environmental, socio-ethical, economical radar diagrams showing improvements. Visualisation of the interactions that support sustainability improvements	**SDO toolkit - radar** **Sustainability interaction story-spot**

Environmental, socio-ethical and economic assessment

The *aim* of this process is to assess the potential improvements that the system concepts could generate from an environmental, socio-ethical and economic (Planet, People, Profit) point of view. This process is fundamental in order to understand whether there are still any unresolved critical points and also, if more than one concept has been developed, to decide which one is more promising. The *result* will be a description, for each concept, of the potential improvements offered (for every criterion of each sustainability dimension); a visualisation of these improvements by means of a radar diagram; and a visualisation of the interactions that illustrate improvements. Suitable *tools* include the *SDO toolkit* (section on Checklist Concept and radar) for the first two points and the *Sustainability interaction story-spot* for the third point.

Key questions:

- What are the potential environmental, socio-ethical and economic improvements that the system concept can generate?
- Does the system concept have any critical points from an environmental, socio-ethical and/or economic point of view? Do any of its elements need redesigning?

4.2.4 Designing (and engineering) the system

The aim of this stage is to itemise the specific requirements of the system concept to enable its implementation.

The processes connected to this stage are described below.

Detailed system design

The *aim* of this activity is to develop the system concept in detail, defining: the set of products and services that make up the offer; all the actors (both primary and secondary) involved in the system together with their roles and interactions; all the interactions between actors and client/end user that occur during delivery of the offer; all the elements (both material and non-material) required for delivery of the offer and who will design/produce/deliver them. Various tools may be used to support the designing and visualisation of the various aspects (see Table 4.5).

Key questions:

- What products and services make up the system? What are the main primary and secondary functions delivered? What value is perceived by the user? How does the client/end user interact with the offer system?
- Who are the actors (both primary and secondary) that take part in the system? What kind of interactions (partnerships, agreements) do they have? What are their respective roles and interactions in delivering the offer?
- What material and non-material elements are required to deliver the offer? Who will design/produce/deliver them?

Sufficiency system implementation

The *aim* of this DSE stage is to refine the details of the new Sufficiency PSS concept regarding its operational steps, the roles of both the system providers and the users,

and solutions that are necessary in the operation. It is then clarified what components are needed to support each operating step of the new system, classified into five categories: tools, interaction rules, required competences, supplied information and context.

Environmental, socio-ethical and economic assessment

The *aim* of this activity is to assess more accurately the environmental, socio-ethical and economic improvements that the system innovations will produce once implemented. The *result* will be a more detailed description of the potential improvements for each project (for every criterion of each sustainability dimension), a visualisation of these improvements by means of a radar diagram, and a visualisation of interactions that illustrate the improvements. Suitable *tools*, as above, include the *SDO toolkit* (section Checklist Concept and radar) for the first two points and the *Sustainability interaction story-spot* for the third.

Key questions:

- What environmental, socio-ethical and economic improvements can be expected from the implementation of the system innovations designed?

Sufficiency design evaluation

The aim in this DSE stage is to evaluate the results of the newly designed system in two aspects: the 'improvement' of the new Sufficiency PSS and the 'balance' of its sufficiency improvements. To achieve this, the first step is to visualise the new Sufficiency PSS's Sufficiency Level 'balance' of each dimension: People, Planet, Profit and Technology (using four separate bar charts). The designer then makes a comparison whether the existing situation becomes enhanced or worsens with the newly designed system regarding the three components of sufficiency: Moderation, Reasonableness, and Self-Immunity. The second step is to evaluate whether the offers in the new Sufficiency PSS have improved each stakeholders' conducts and behaviours in the system and the improvements in all dimensions have been developed in equilibrium (using only one overall bar chart). The *tool* to support this is the Sufficiency Economy Balance Tool.

Table 4.5 **System designing and engineering: processes, sub-processes, results and tools. System design tools for sustainability described in detail in the following sections are shown in bold**

	Processes	Sub-processes	Results	Tools
Designing (and engineering) a system	Detailed system design	Defining the specifics of interactions between (primary and secondary) actors in the new system	Detailed map of the principal and secondary actors and their relationships (material, information and money flows)	**System Map**
		Defining the specifics of the set of products and services that make up the offer (primary and secondary functions)	Images and texts of the principal and secondary functions delivered to the user	**Offering diagram**
		Defining the specifics of services to the user and the interactions of the other actors during delivery of the offer	Narration of the sequence of all the interactions occurring in the production and delivery of the offer	**Interaction storyboard Animatic, System concept Audiovisual**
		Specifying the role, contribution and motivations of each actor	Matrix indicating the contribution made by each actor to the partnership, the expected benefits and potential conflicts	**Motivation matrix**
		Defining material and non-material elements required for delivery of the offer (and defining who will design/ produce/deliver it	Map indicating the elements required by the system and the role of the actors in designing, producing and delivering it	**Solution element brief**
	Sufficiency system implementation	Constructing a thorough plan of operation	Document and storyboards that detail the new Sufficiency PSS regarding its operation, roles, solutions and what components are needed in each operating step	**Interaction storyboard** (as above)
		Defining and designing components	List and design of the components that support the new Sufficiency PSS in five categories: tools, interaction rules, required competences, supplied information and context	DSE Worksheet 12 (List of Components)

	Processes	Sub-processes	Results	Tools
Designing (and engineering) a system	**Environmental, socio-ethical and economic assessment**	Defining environmental, socio-ethical and economic improvements to be expected from implementation of the system	Definition of improvement potentials for every criterion of each sustainability dimension	**SDO toolkit—*checklist concept***
		Visualisation of results	Radar diagram indicating improvements Visualisations of interactions	**SDO toolkit** - **radar** **Sustainability interaction story-spot**
	Sufficiency design evaluation	Evaluating the Sufficiency of the new PSS	Visualisation of the degree of 'improvement' of the new Sufficiency PSS in comparison to the existing one on a scale of 0–6	**DSE Worksheet 5:** ***Part 1: DSE Checklists*** ***Part 2: Defining Sufficiency level*** ***Part 2: Evaluate the Sufficiency Improvement***
		Evaluating the degree of Sufficiency in terms of 'balance' and in comparison to the existing system (in each component as well as overall balance of all 4 dimensions)	Visualisation of the 'balance' of the new Sufficiency PSS's Sufficiency Level in four dimensions (People, Planet, Profit and Technology) and in comparison to existing system	**DSE Worksheet 13:** ***Sufficiency Economy Balance Tool***

4.2.5 Communication

The communication stage, which works across all the others, aims to communicate the general characteristics of the solution designed, and above all those regarding sustainability, to the outside world. Some of the tools used in the previous stages to design and visualise the various elements of the solution are also used in this stage to support communication.

The basic aim is to provide a document indicating:

- **The design priorities for sustainable solutions.** The priority criteria are shown for each dimension of sustainability (as concerns the existing system), to steer the designing process towards sustainable solutions
- **The general characteristics of the product-service system.** The elements that make up the system innovation are described: i.e. the set of products and services that the offer consists of; the primary and secondary actors involved in the system and their respective roles and interactions; and the interactions between the actors and client/end-user

- **The sustainability characteristics of the product-service system.** The potential improvements (from an environmental, socio-ethical and economic point of view) to be gained from the implementation of the solution are shown, with an indication of the elements of the system that will deliver these improvements
- **Sufficiency design communication.** This step is vital in the DSE process, as the concepts of PSS and DSE are unfamiliar to most designers. The *aim* is therefore not only to communicate the new system to clients and stakeholders with respect to how the system operates, it is also to convince the clients and/or service provider to accept the newly designed Sufficiency PSS. Effective tools include the Interaction storyboards and story-spot.

Table 4.6 **Communication: processes, sub-processes, results and tools. System design tools for sustainability described in detail in the following sections are shown in bold**

	Processes	Sub-processes	Results	Tools
Communication	Drawing up the documentation for the sustainability communication	Communicating design priorities for sustainable solutions	Document indicating design priorities for each dimension of sustainability	**SDO toolkit—radar**
		Communicating the general characteristics of the product-service system	Document with the general characteristics of the innovation actors making up the system and their interactions set of products and services making up the system interactions between user and offer Audiovisual document providing diverse mental images involved in developed system concepts	**System Map** **Offering diagram** **Interaction storyboard / spot** **Animatic** **System concept** **Audiovisual miniDoc**
		Communicate sustainability characteristics of the product-service system	Document with the sustainability characteristics of the solution Environmental, socio-ethical and economic improvements Elements of the system bringing improvements	**SDO toolkit—radar** **Sustainability interaction story-spot**

4.3 Design tools for SDS

This section describes several tools that may be used to support the various stages of the MSDS (Methodology for System Design for Sustainability). The tools can be classified into two basic groups:

- Sustainable system design steering tools
- Stimulus and support tools for the generation of ideas and strategic to system design

The first group, **sustainable system design steering tools**,[22] consists of tools developed to steer the system design process towards environmentally, socio-ethically and economically sustainable solutions.

These tools are intended to:

- Facilitate the identification of design priorities: Sustainability Design-Orienting (SDO) toolkit—section 'Set Priorities'
- Steer the generation of ideas towards sustainable solutions: *SDO toolkit—section 'Orientate Concept'*
- Define the potential (environmental, socio-ethical and economic) improvements delivered by the solutions designed: *SDO toolkit—sections 'Check Concept' and 'Radar'*
- Visualise the sustainability characteristics of the system innovations designed: *Sustainability interaction story-spot*

It is important to stress that if the aim is to define sustainable solutions, it is more effective for the purposes of the end results to integrate these tools during the initial stages of the designing process.

The second group includes **tools** developed, on the one hand, **to support and stimulate idea generation at system level** and on the other **to facilitate their organisation and communication**. Among the tools we shall be describing we particularly highlight the *Polarities diagram* and the *Satisfaction system map*.

The **strategic tools for system design**[23] have been developed to facilitate the co-production and visualisation of the various elements in a (product-service) system innovation. More specifically, these tools are aimed at designing and visualising:

22 Besides the tools listed here there are others with similar purposes. These tools will not be described in this publication; the full range can be found on the website www.lens.polimi.it in the 'Tools' section.

23 Besides the tools listed here there are others with similar purposes. These tools will not be described in this publication; the full range can be found on the website www.lens.polimi.it in the 'Tools' section.

- The functions delivered by the set of products and services that make up the offer: *Offering diagram*
- The structure of the system (actors and their interactions) required to produce and deliver the offer: *System map*
- The interactions occurring between the client/end-user and the system during offer delivery and those that occur between the various actors in the system during its production and delivery: *Interaction table, the Interaction storyboard, the System concept Audiovisual*
- The relationships between the various actors in the system: *Stakeholder motivation matrix*
- The role of the different actors in the design/production/delivery of the various (material and non-material) elements that make up the system: *Solution element brief*

As well as supporting the visualisation/designing of the various system elements, these tools have also been created to facilitate a co-designing process between the various actors.

The design tools will be described according to:

- Their aims
- Their integration into the MSDS design process
- How they are used
- Their results
- Their availability and resources required

The tools will be presented in the following order.

First, tools to orientate the design process towards sustainable system innovation:

- Sustainability Design-Orientating tool-kit (SDO)
- Sustainability interaction story-spot
- Sufficiency Economy Checklists
- Sufficiency Economy Guidelines
- Sufficiency Economy Balance Tool

Subsequently other tools, to design system innovations in general:

- Stakeholder system map
- Satisfaction system map
- Interaction table (storyboard)

- Offering diagram
- Polarity diagram
- Solution element brief
- Stakeholder motivation matrix
- MiniDOC
- System concept audiovisual
- Animatic

4.3.1 Sustainability Design-Orienting toolkit (SDO)[24]

Aims

The objective of this tool is to orient the design process towards sustainable system solutions. This happens thanks to the different functions of the tool, which is able to support designers in: setting sustainability priorities; analysing best practices; using sustainable design-orienting guidelines; and checking and visualising the potential improvements in relation to an existing reference system.

It is basically a tool that is able to support several functions, with a modular structure so that it can be used as a whole or in part, according to the special needs and circumstances of each design project.

The purpose of the tool is:

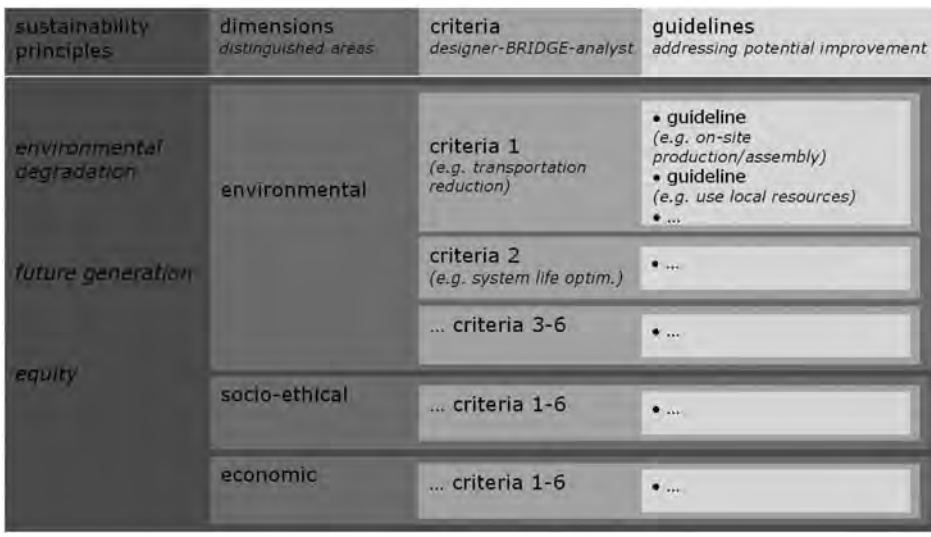
- To define the *design priorities* for all three dimensions of sustainability (e.g. for the environmental dimension, to ascertain whether it is more important to optimise the life of the system, or to reduce resources, etc.). This is done by using checklists to analyse the existing system (*SDO section: 'Set Priorities')*
- To stimulate the *generation of ideas* for potentially sustainable systems. This is done by using design criteria and guidelines oriented towards sustainability (*SDO section: 'Orientate Concept')*
- To *assess potential improvements*, or any *worsening*, associated with the three dimensions of sustainability compared to the existing system. This is done by using checklists to compare the designed solution and the existing system, and radar diagrams to visualise the results of the analysis (*SDO section: 'Check Concept'* and *'Radar')*

24 A tool developed by Carlo Vezzoli and Ursula Tischner included in the MEPSS EU 5th FP, Growth projects, updated once for the UNEP project and updated once more for the LeNS EU-funded project.

It is important to stress that these three basic functions of the tool, which refer to all three dimensions of sustainability, integrate with the different stages of the designing process in increasing detail.

Let us now review how the tool is structured. The key elements in the *SDO* structure are the criteria and guidelines, set up in a multi-dimensional structure. As shown in Figure 4.2, the three sustainability dimensions are taken into consideration, environmental, socio-ethical and economic, and for each dimension there are six *criteria*. Each of these criteria is used both as a way of assessing a given system and as a way of steering the design process, and each in turn groups together a series of *guidelines*.

Figure 4.2 **SDO structure: sustainability dimensions, criteria, guidelines**



Criteria for the environmental dimension:

- Life optimisation
- Reduction in transport/distribution
- Reduction in resources
- Minimisation/valorisation of resources
- Conservation/biocompatibility
- Non-toxicity

Criteria for the social-ethical dimension:

- Improvement of employment/working conditions
- Justice and equity on the part of stakeholders
- Enabling of responsible, sustainable consumption
- Fostering and integration of the weak and marginalised
- Improvement of social cohesion
- Reinforcement/valorising of local resources

Criteria for the economic dimension:

- Market position and competitiveness
- Profitability/added value for businesses
- Added value for clients
- Long-term business development
- Partnership/cooperation
- Macro-economic effect

This tool has been developed to be a 'bridge' between the language, data and tools of the sustainability assessment 'world' and the designer's 'world'. It is essentially a qualitative tool applicable to complex systems.

Integrating the tool into the MSDS designing process

The *SDO* has been developed for use in all stages of the methodology:

- In **Strategic analysis,** the *SDO* can be used to:

A: identify design priorities for all dimensions of sustainability
B: analyse cases of excellence from an environmental, socio-ethical and economic point of view

- In **Exploring opportunities,** the *SDO* can be used to:

C: generate sustainability-orientated ideas (at system level)

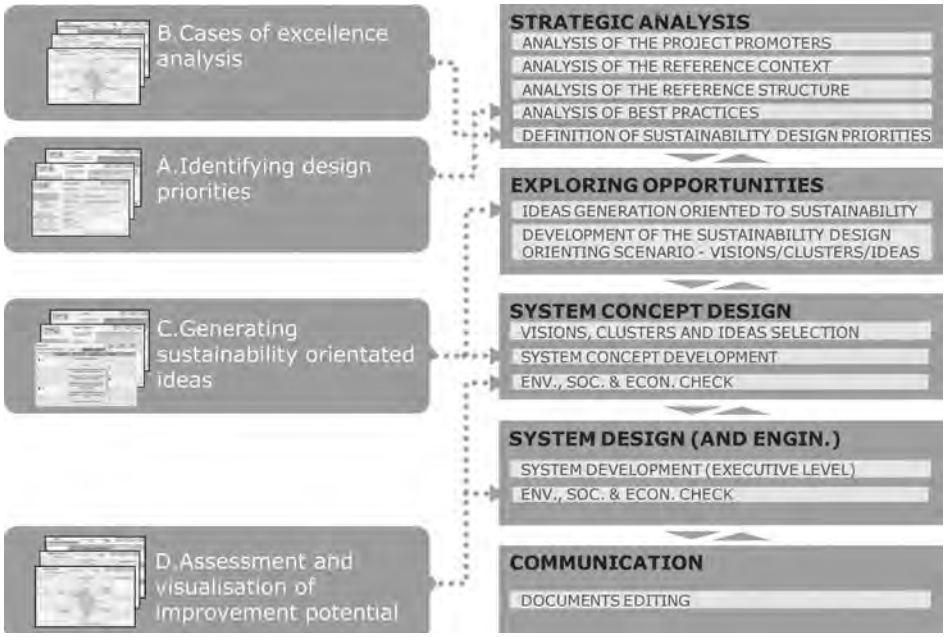
- In Designing system concepts, the *SDO* can be used to:

C': generate sustainability-orientated ideas (at product and service level)
D: check and visualise potential improvements
D': if necessary, redefine design priorities

- In System designing and engineering, the *SDO* can be used to:

D": check and visualise potential improvements

Figure 4.3 **Integrating SDO into the MSDS designing process**



How to use the tool

The following describes how to use the tool with reference to the stages of the MSDS methodology.

Start up

Create a new project on the opening screen by clicking on 'New', inserting the title, and clicking on 'Ok'. (To access the project again select 'Load', insert the project name, and click 'Ok'). A page called 'Project Record' will appear, where it is possible to insert general information about the project, indicate the satisfaction unit (i.e. the demand for well-being to be met), and the reference context (or existing system).

Figure 4.4 **SDO toolkit: opening screen**

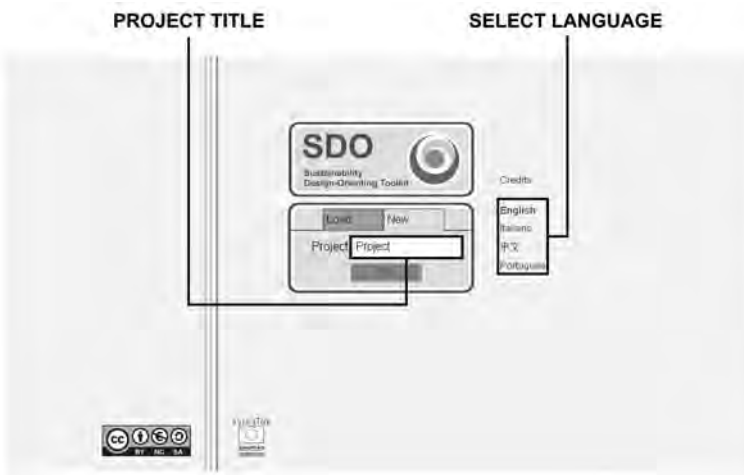
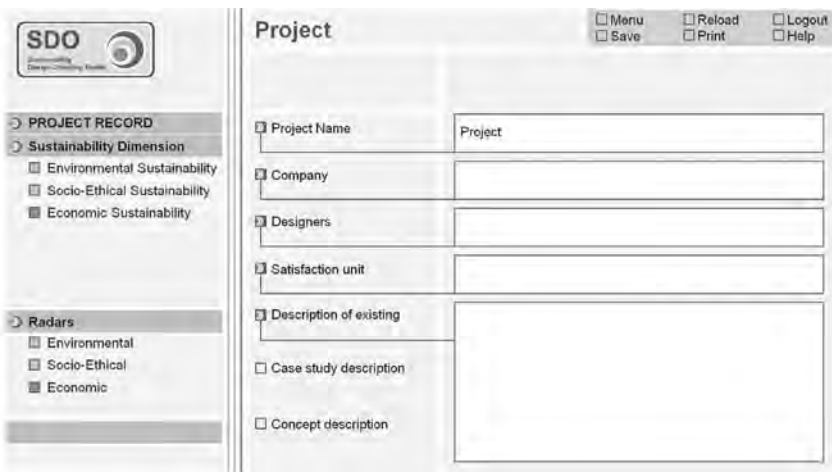


Figure 4.5 **SDO toolkit: enter starting data**



1. Strategic analysis

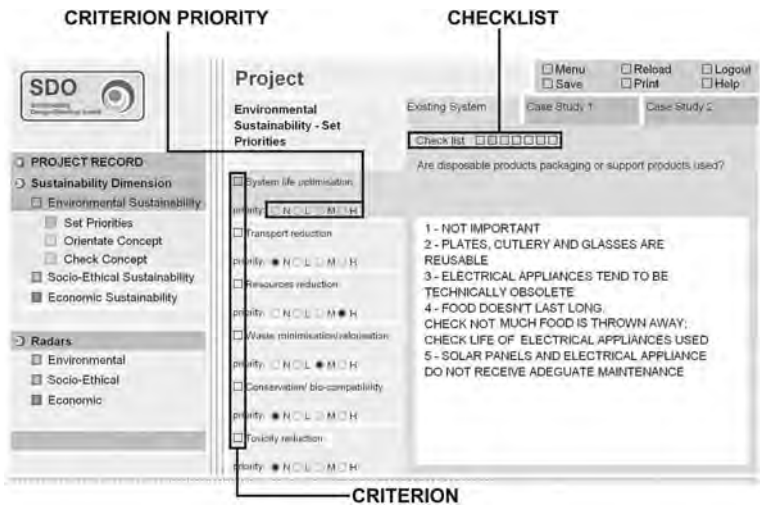
A. Identifying design priorities

The aim is to analyse the existing system in order to define design priorities according to the three dimensions of sustainability. These priorities form the basis for steering design decisions towards potentially more sustainable solutions.

For each dimension of sustainability the system is assessed by answering a series of checklists grouped under six different criteria. To do this, you must select a dimension (e.g. environmental) and click on 'Set Priorities': six corresponding criteria appear, each associated with a series of checklists; for every checklist it is possible to write replies and comments in the field provided.

After answering the various checklists it is possible to define a design priority for each criterion by clicking on 'H' (= High), 'M' (= Medium), 'L' (= Low) or 'N' (= No) priority.

Figure 4.6 **SDO toolkit: analysing existing system and defining design priorities**



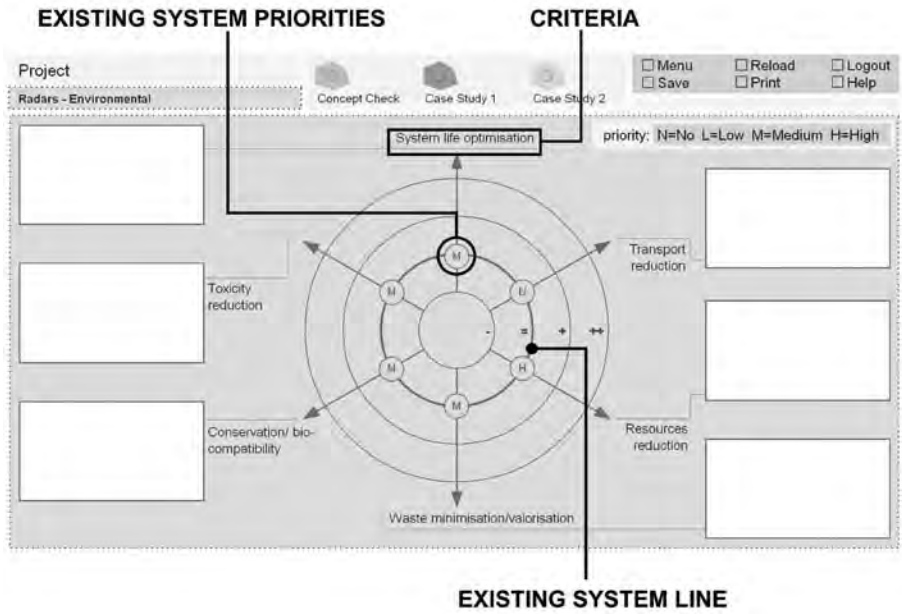
By clicking on the 'Environmental' radar it is possible to visualise the graphic result of the process. The radar diagram shows the design priorities for each criterion. In addition, it is possible to fill in the white spaces corresponding to each criterion with the most critical elements of the existing system; the visualisation may be used as a brief to support the subsequent generation of ideas.

We must stress once more that the importance of defining design priorities lies in being able to identify the most important design criteria on which to focus during the actual designing stage.

B. Analysing cases of excellence with sustainability characteristics

In order to have sustainable inputs and insights for the design process, existing sustainable solutions should be examined. The *SDO* tool enables us to compare these solutions with the existing system so as to highlight the environmental, socio-ethical and economic qualities.

Figure 4.7 **SDO toolkit: visualising design priorities**



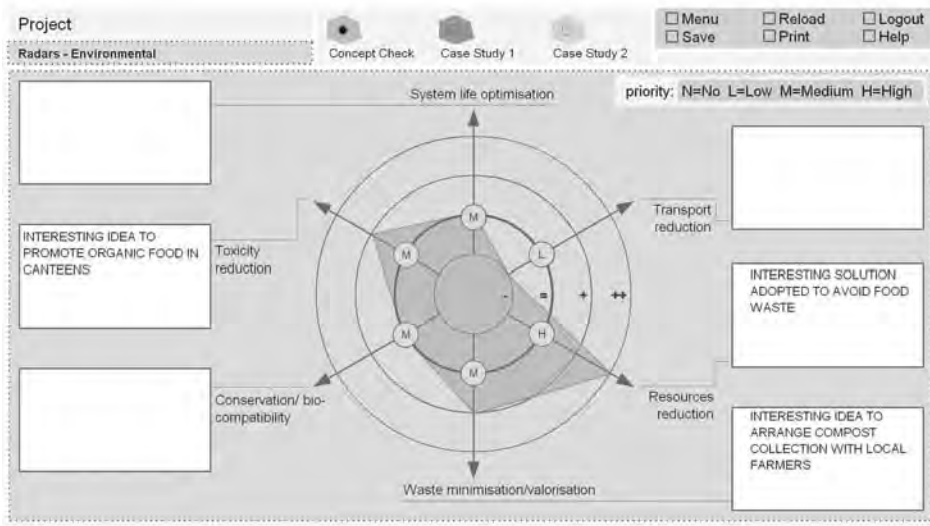
The assessment process is similar to that described in point A. By selecting a dimension and clicking on 'Set Priorities' and then on 'Case Study', six corresponding criteria will appear, each one associated with a series of checklists; it is possible to enter replies and comments in the field provided for each checklist.

After responding to the various checklists it is possible to indicate the improvement on the existing situation for each criterion by choosing between: radical improvement (++), incremental improvement (+), no significant change (=), and worse (–).

By clicking on 'Radars' and selecting the radar area corresponding to the case study, it is possible to visualise the improvements for each criterion. In this case, too, the text boxes can be used to enter the key elements of the solution; the visualisation can be used as a stimulus for the subsequent generation of ideas.

The *SDO* allows two cases of excellence to be entered.

Figure 4.8 **SDO toolkit: visualising improvements on the existing system shown in a case of excellence**



2. Exploring opportunities

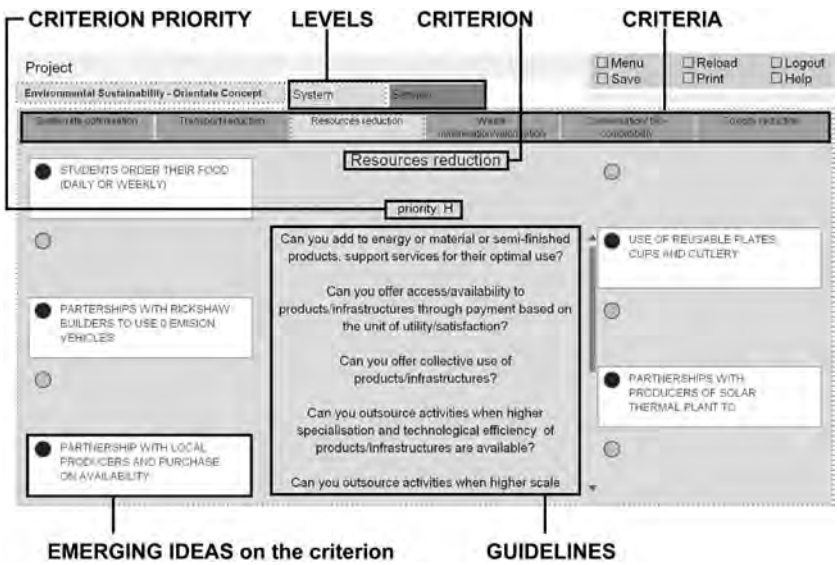
C. Generating sustainability-oriented ideas

The aim is to facilitate the generation of sustainability-oriented ideas. To do so, we can use a series of design guidelines for each criterion, for support and stimulus.

Within the *SDO*, in the menu on the left, select a sustainability dimension (e.g. environment) and click on 'Orientate Concept'; at the top, select 'System'. Again at the top, six design criteria will appear, and by clicking on these it is possible to see the priorities assigned previously, with a set of corresponding guidelines. These guidelines will stimulate the generation of ideas, which can be noted on the virtual 'post-its' to be found at the sides of the screen.

Obviously, as mentioned, the idea generation session must focus mainly on the highest priority criteria. For example, if *Resource reduction* is a high priority, you should start with the idea table referring to this criterion, getting inspiration from the related guidelines. At the same time, if *Transportation/distribution reduction* has a low priority, you will give less attention to it (or even no attention if it has 'No' priority).

Figure 4.9 **SDO toolkit: (system level) idea generation table for the environmental dimension**



3. Designing system concepts

C'. Generating sustainability-oriented ideas

The idea is to facilitate the generation of sustainability-oriented ideas at product and service level.

In the menu on the left, select the sustainability dimension and click on 'Orientate Concept'; at the top select 'Service'. As in the generation of ideas at system level, it is possible to select the various design criteria, visualising the priority level assigned and the associated guidelines. The guidelines are used to support idea generation; ideas can be noted on the virtual 'post-its', which can be opened at the sides of the screen.

D. Checking and visualising potential improvements in the system concept developed

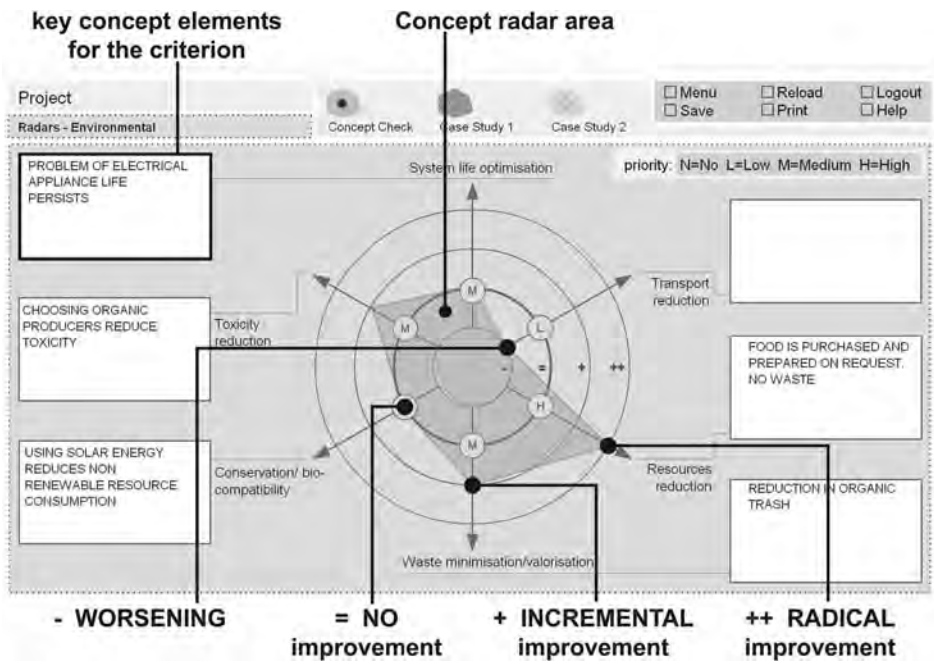
The aim is to analyse the system concept to identify its potential improvements over the existing system.

Select a sustainability dimension (e.g. environment) and click on 'Check Concept'. At the top, click on 'Concept Description' and enter a summary of the system concept developed in the text field provided. Answering the checklists helps to define the improvements offered by the designed solution over the existing system. For each criterion it is possible to select: radical improvement (++), incremental improvement (+), no significant change (=), or worse (–).

Going through the checklists also helps us to ascertain the level of improvement offered by the designed system compared to the benchmark excellence case, as well as how this too might be open to improvement.

By clicking on 'Radars' and selecting the 'Concept Check' radar area you can visualise the potential improvements on the initial system, or case study, for each criterion. Here too the key elements of the solution can be written up in the text boxes.

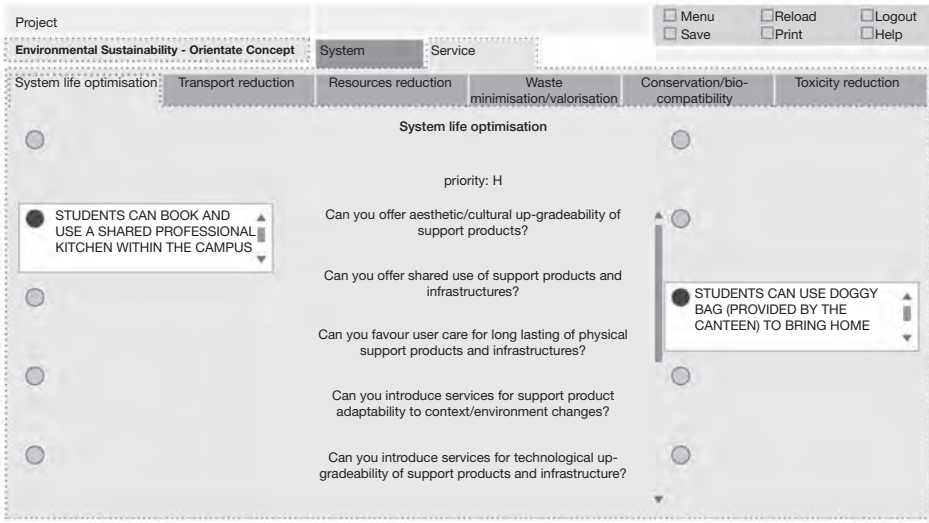
Figure 4.10 **SDO toolkit: radar with potential product-service system**



C". Generating sustainability-focused service ideas (guidelines level 2)

In the 'Sustainability Dimension' section of the 'Menu', choose a dimension and go to 'Orientate Concept'; select 'Service' on the top. The criteria are visualised, with the related priorities you defined and with a series of related guidelines (level 2–service). Perform a brainstorming session starting from those criteria having both the highest priorities (reference existing system) and the lowest improvements (System concept): write up the emerged ideas in the 'post-it' boxes (click on the circles on the left and right sides).

Figure 4.11 **Image of ideas table/guidelines level 2—service with some ideas written in the 'post-it' boxes**



D'. Check and visualise sustainability improvements of developed product-service system concept

In the 'Sustainability Dimension' section of the 'Menu', choose a dimension and go to 'Check Concept'. Write in the text box a synthesis of the system concept developed (if updating what was written for the System). The button 'Check Concept' of each one of the sustainability dimensions leads you to the *checklists* (one for each of the dimensions), which will help you to define (if updating what was written for the System concept) the improvement in relation to the existing system.

Mark the improvement: worsening (–), equal (=), incremental improvement (+), radical improvement (++).

Going through the checklist you may realise how the System concept can be improved or changed; if so click on 'Concept Description' to modify the concept description and update the previous concept definition.

If you go to the 'Radar' section you can visualise the graphical result of the improvement. Select the concept and the sustainability dimension you are interested in. The radar diagrams will enable a visualisation as an area (shaped like a boat sail) which represents the improvement of the System concept in relation to the existing system (bold circle) or to the case study.

4. Designing and engineering the system

D". Checking and visualising the potential improvements offered by the product-service system

As for point D', for each criterion answer the checklist and mark the improvement: radical improvement (++), incremental improvement (+), no significant change (=), or worse (–).

By clicking on 'Radar' you can see the graphic result of the improvements.

Results

The possible results from the various *SDO* functions are as follows:

- Definition of the design priorities (from an environmental, socio-ethical and economic point of view) for the existing system
- Definition of different sets of sustainably oriented (system, service and product) ideas
- Radar diagram visualisations of the existing system to be derived from the designed solution
- Radar diagram visualisations of the potential environmental, socio-ethical and economic improvements that characterise a case of excellence

Tool availability and resources required

The *SDO toolkit* is open-source, copyleft software that can be used online (www.sdo-lens.polimi.it[25]) or downloaded (from www.lens.polimi.it, 'Tools' section) and installed for use on a local area network (LAN).[26]

The tool may be used by a single designer, though the support of a multi-disciplinary team is preferable. It is also advisable to involve the various system actors, clients and/or end-users.

This tool requires at least:

- 30 minutes to define design priorities (for each sustainability dimension)
- 30 minutes to generate ideas (for each dimension)
- 60 minutes to assess improvements (both for the designed solution and for a case of excellence)

25 Versions available in Italian, English, Portuguese and Chinese.

26 Since the locally installable version is open-source it can be translated into other languages and modified according to project needs.

4.3.2 Sustainability interaction story-spot[27]

Aims

The *Sustainability interaction story-spot* is a co-designing tool, above all for visualising. Its purpose is to describe, succinctly and effectively, the salient elements of a product-service system in relation to given objectives (e.g. how the solution designed achieves certain environmental and socio-ethical aims).

It is basically an *Interaction table* focusing only on specified interactions. The display, to be visualised on a single screen/page, contains the following key elements:

- The key interactions of the client/end-user with the offer delivered by the system
- The key *interactions of the various actors* during production and delivery of the offer
- How *the designed solution achieves given aims* (e.g. how the solution produces the desired environmental and socio-ethical improvements)

The tool is also useful when it is necessary to visualise and communicate several hypotheses of system concepts to the actors involved. On such occasions it is more effective to synthesise and communicate only the key elements of the various system concepts.

Integrating the tool into the MSDS design process

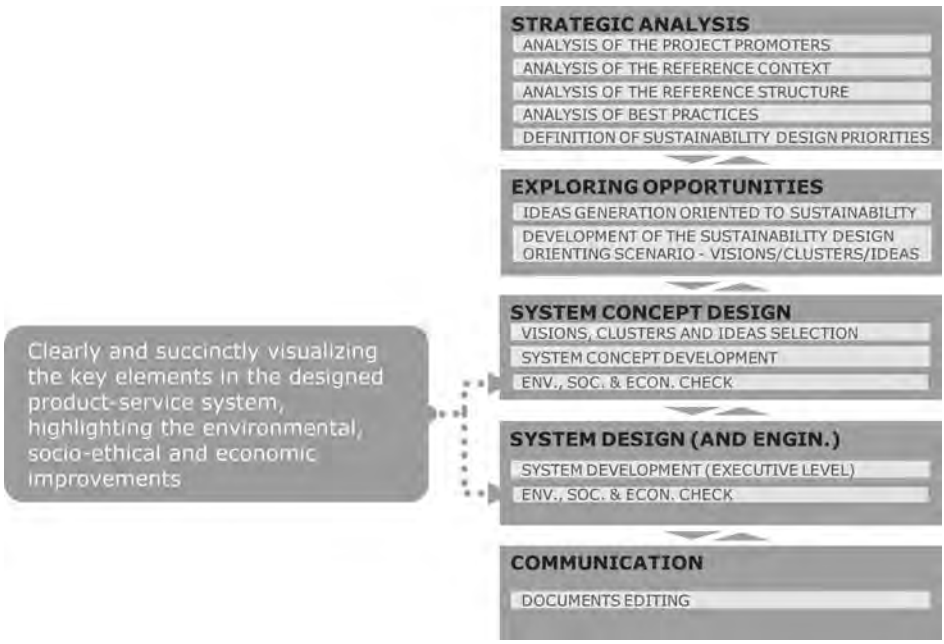
The *Sustainability interaction story-spot* may be used:

- In System concept designing and in System designing (and engineering) to:

Visualise the key elements of the designed product-service system succinctly and effectively, and highlight the environmental, socio-ethical and economic improvements it offers

27 The tool was developed by the Design and System Innovation for Sustainability research unit (Dipartimento INDACO, Politecnico di Milano). For further information see Vezzoli (2010).

Figure 4.12 **Integrating the Sustainability interaction story-spot into the MSDS design process**



How to use the tool

The tool requires the use of graphic image processing software and slide show software (e.g. Microsoft PowerPoint or the equivalent in Open Office) for the visualisation.[28]

The composition, which must be visualised on a single screen, shows two lines of interaction: one focusing on the user and the other on the actors delivering the offer; these two lines of interaction are differentiated by background colour (Figure 4.13). Each individual interaction consists of (Figure 4.14):

- An image in which the colour of the actor matches the background (for suggestions about how to process the image see the section dedicated to the *Interaction table*)
- A brief description

At the bottom of the visualisation it is possible to enter notes and link these to the corresponding interaction (Figure 4.15).

28 It is possible to download a basic model of the Interaction story-spot from www.lens.polimi.it, in the 'Tools' section, with a guide to its use.

Figure 4.13 **Two lines of interaction are shown in the Sustainability interaction story-spot: front office and back office. The different background colour differentiates the two lines**

Figure 4.14 **The elements that make up a single interaction in the Sustainability interaction story-spot are the images, background colour, characterising text and description**

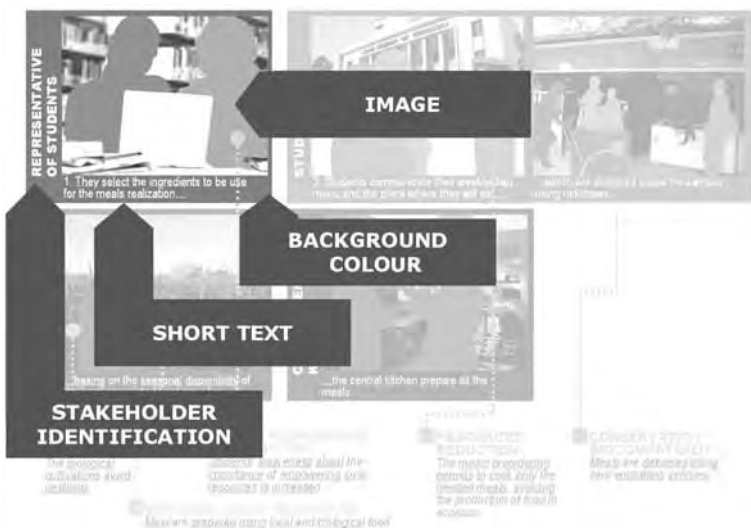


Figure 4.15 **The bottom part of the Sustainability interaction story-spot is dedicated to notes linked to the corresponding interaction**

Results

The result is a visualisation that shows the key elements of the product-service system succinctly and effectively, linking them to specified aims (e.g. environmental or socio-ethical improvements etc.).

Tool availability and resources required

The *Sustainability interaction story-spot* requires the use of graphic image processing software and slideshow software. Alternatively, if the *Interaction table* (see Section 4.3.8) has already been created, it is possible to start with this, created with spreadsheet software, selecting only the key interactions.

As far as using the tool is concerned, basic graphic skills are required to create the images (using photo editing software). The *Sustainability interaction story-spot* can be managed within the slideshow software (or spreadsheet software) by any member of the design team.

The creation of a *Sustainability interaction story-spot* requires an approximate minimum technical time of:

- 4 hours if starting from zero
- 30 minutes if starting with an existing *Interaction table*

4.3.3 Sufficiency Economy Checklists

Aims

The Sufficiency Economy Checklists support assessment of people's way of living/behaving at all levels towards the middle path (i.e. Sufficiency), and they help to define the sufficiency level of the existing system. The checklists cover four dimensions (People, Planet, Profit and Technology) within the three core components of the Sufficiency Economy Philosophy (Reasonableness, Moderation, and Self-Immunity).

The three common dimensions in the definition of sustainable development, People (socio-ethical), Planet (environmental) and Profit (economic), are thus present in DSE with an additional focus on Technology. Choosing an appropriate technology is clearly one of the most critical conducts that can prevent imbalance of a system, a lesson learned from a past of inappropriate investments, technology push and resultant negative impacts.

Integrating the tool into the MSDS design process

The *Sufficiency Economy Checklists* may be used:

- In Strategic analysis to:

Assess the Sufficiency Level of the existing situation (to see if or how users' or system providers' conducts are in line with the principle of the Sufficiency Economy Philosophy, SEP)

How to use the tool

There are two steps when using the Checklists.

Step 1: Analysing Sufficiency Level through Sufficiency Economy Checklists

The designer goes through Worksheet 5 Part 1 and ticks ✓ the boxes ☐ beside the relevant points in the checklists, in the four dimensions: People, Planet, Profit and Technology (see Figure 4.16).

Step 2: Defining Sufficiency Level of existing system

The designer evaluates the Sufficiency Level of the existing system, indicating the defined Sufficiency Levels in the evaluation box on a scale of 0–6 (Worksheet 5 Part 2).

Sufficiency Degree:

0 = unable to survive/sustain

1 = almost sufficiency at the household level

2 = sufficiency at the household level

3 = almost sufficiency at the community level

4 = sufficiency at the community level

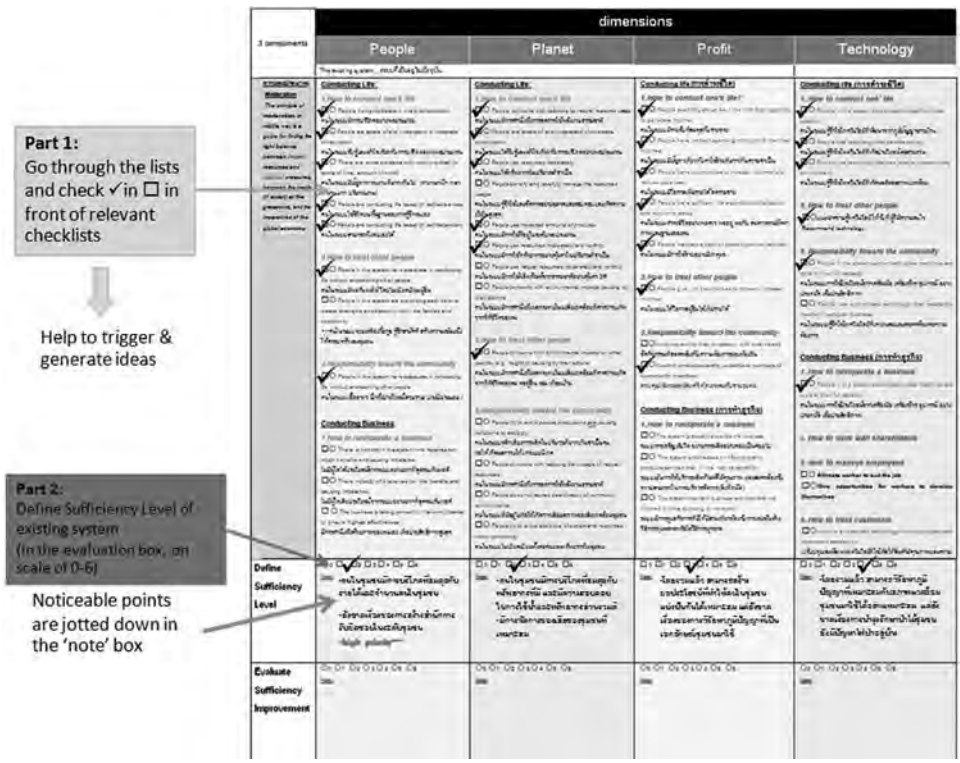
5 = almost sufficiency at the national level

6 = sufficiency at the national level

Salient issues are jotted down in the 'note' box.

An example of checklists and the assessment is partly illustrated in Figure 4.16.

Figure 4.16 **Defining Sufficiency Level**



Results

The checklists assess the sufficiency level according to two aspects: how the users conduct their lives and how the system provider conducts its business.

Conducting life:

How to conduct one's life

How to treat other people

Responsibility to the community

Conducting business:

How to run/operate a business

How to work with shareholders

How to manage employees

How to treat customers

How to cooperate with partners/alliances/competitors

How to deal with stakeholders

How to contribute to the community

This process generates ideas that can be noted down and used in subsequent stages.

Tool availability and resources required

The Design for a Sufficiency Economy Worksheets are available for download (from www.lens.polimi.it, 'Tools' section). The Worksheets are based on spreadsheet software (e.g. Microsoft Excel or the equivalent in Open Office).

4.3.4 Sufficiency Economy Guidelines

Aims

The Sufficiency Economy Guidelines consist of statements that steer designers towards developing a framework or mind-set based on the Sufficiency Economy Philosophy (SEP). The guidelines help designers to come up with strategies suitable for specific situations as well as potential ideas and directions for the new system. By exploring the competences of the 'company' or organisation, opportunities to design a new Sufficiency PSS can be identified that acknowledge two conditions of the SEP.

> Condition 1: Knowledge (wisdom) includes accumulating information with insight in order to understand its meaning with care and prudent usage.
>
> Condition 2: 'Morality' is essential and includes virtue, ethical behaviour, honesty, tolerance, and perseverance where one does not exploit others.

The objectives of the Guidelines are therefore to assist designers in creating a holistic concept of products/services/systems or ways of life involving moderation and contentment while emphasising the wise use of knowledge with due consideration. In addition, they seek to explore the potential of users and companies to build on values such as integrity, diligence, harmlessness and sharing.

The Sufficiency Economy Guidelines assist designers to explore new ideas on achieving sufficient ways of living at three stages of the Sufficiency Economy: sufficiency at household level, at community level, and at national level. At the time of writing, the tool was developed up to the point of providing guidelines at community level.[29]

Integrating the tool into the MSDS design process

The *Sufficiency Economy Guidelines* may be used:

- In Exploring opportunities to:

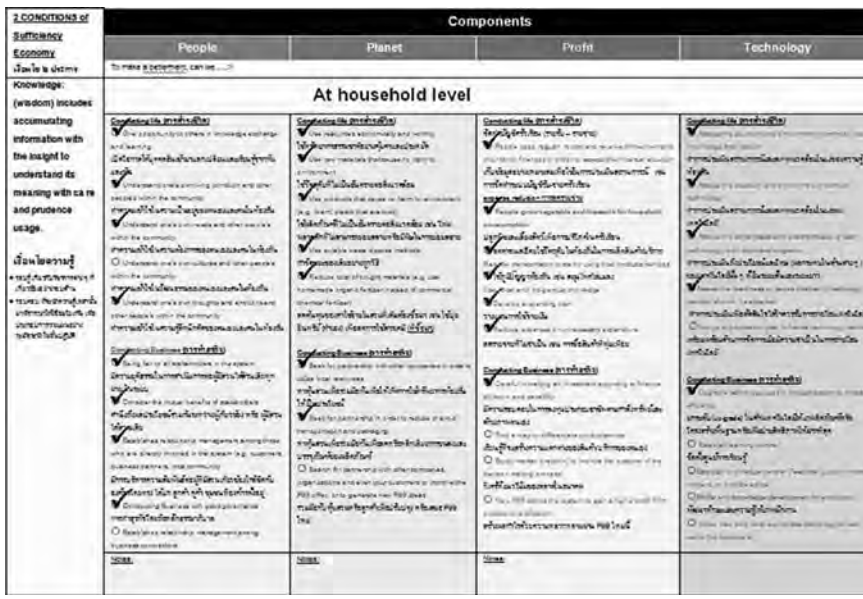
Generate ideas oriented to the SEP conditions of knowledge and morality

How to use the tool

The worksheet (Worksheet 8) is completed by the design team, in the same way as the Sufficiency Economy Checklists (see Section 4.3.3).

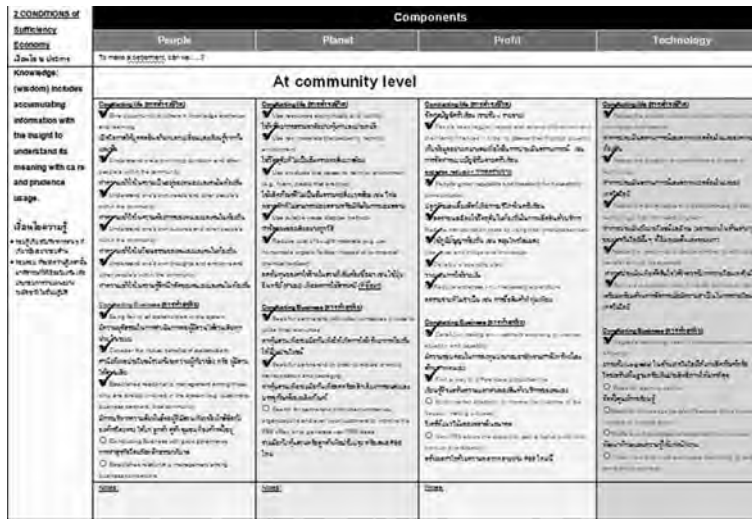
Examples of the guidelines, at household level and community level, are partly illustrated in Figure 4.17 and Figure 4.18.

Figure 4.17 **Sufficiency Economy Guidelines: condition of knowledge (at household level)**



29 The guidelines at national level are not yet defined as this will require a great deal of involvement from governmental bodies.

Figure 4.18 **Sufficiency Economy Guidelines: condition of knowledge (at community level)**



Results

The results are a set of ideas generated from and inspired by discussion around the guidelines, as noted in the Worksheet. The design team can then proceed to the design of the system concept and components.

Tool availability and resources required

The Design for a Sufficiency Economy Worksheets are available for download (from www.lens.polimi.it, 'Tools' section). The Worksheets are based on spreadsheet software (e.g. Microsoft Excel or the equivalent in Open Office).

4.3.5 Sufficiency Economy Balance Tool

Aims

As the ultimate aim of the SEP is to seek to achieve balance and sustainability, when evaluating the success of the outcome emphasis is thus placed on keeping a **balance** among all four dimensions: People, Planet, Profit and Technology.

While the Sufficiency Economy Design Guidelines were developed to help steer new mind-sets in order to design a more sufficient system, the Sufficiency Economy Balance Tool was designed to evaluate and visualise the balance of such progress.

Integrating the tool into the MSDS design process

The *Sufficiency Economy Balance Tool* may be used in various stages of the methodology:

- In **Strategic analysis**, the *Balance Tool* can be used in need assessment to:
  - Visualise the existing situation's Sufficiency Level 'balance' (both regarding the four dimensions, People, Planet, Profit and Technology, and regarding the three components within each dimension: Reasonableness, Moderation and Self-Immunity)
- In **System designing and engineering**, the *Balance tool* can be used to:
  - Visualise the 'balance' of the new Sufficiency PSS's Sufficiency Level (in four dimensions: People, Planet, Profit and Technology)
  - Evaluate whether the offers in the new Sufficiency PSS have been improved over the existing system and the improvements in all dimensions are in equilibrium

How to use the tool

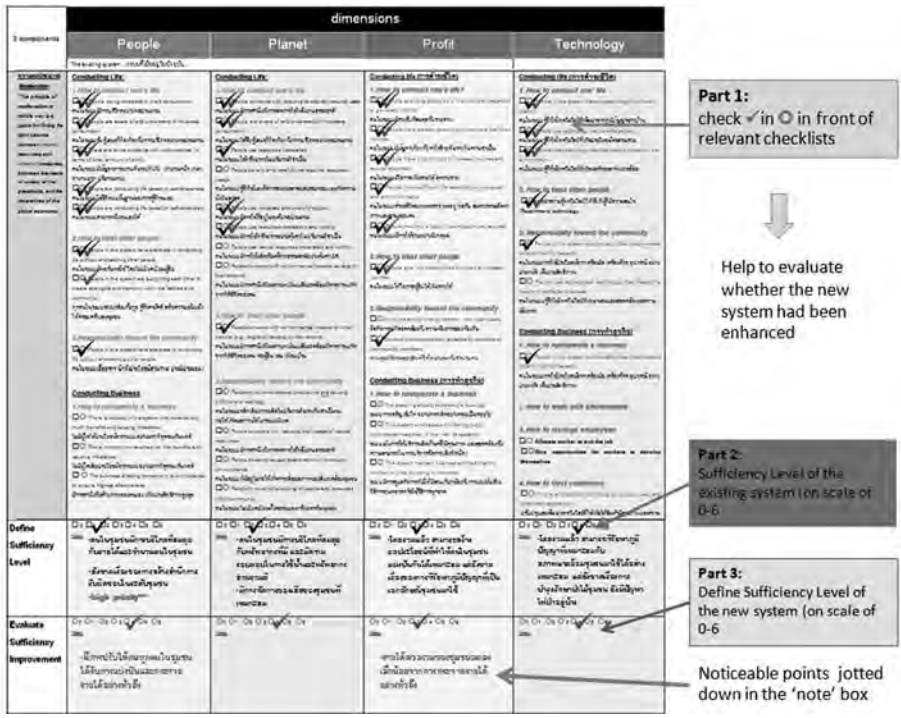
This worksheet is used during the design process in two steps:

- **A. Need assessment:** to visualise how sufficient the existing system is at present
- **B. Design evaluation:** to visualise the development of a new Sufficiency PSS in two aspects

The **first aspect** is to evaluate the *improvement* of the Sufficiency Level. To do this, the designer must:

- Go through the Sufficiency Economy Design Checklists again in Worksheet 5 Part 1, but this time tick off ✓ the achieved points in red ○. Important notes should be jotted down in the box
- Evaluate the Sufficiency Improvement (Worksheet 5 Part 3) of the new SE-PSS on a scale of 0–6 (Figure 4.19). The analysis in this step will reveal whether the new system is better or worse than the existing one
- Feed the values from the Sufficiency Level analysis (on a scale of 0–6) of both the 'existing system' and 'new Sufficiency System' into the datasheet (Worksheet 13) (using the Chart tool in Microsoft Office Excel or equivalent open source spreadsheet program). See Figure 4.20

Figure 4.19 **Evaluating Sufficiency Improvement**



- A bar chart created from the values above will comprise three bi-directional bars, each bar signifying the Sufficiency level of the three components (Reasonableness, Moderation and Self-Immunity). The left side of the bars signifies the existing system while the right side signifies the new Sufficiency System. Figure 4.21 illustrates four separate bar charts showing the improvement of the Sufficiency Level of each dimension
- Compare the result of the 'Sufficiency Level' of the existing and new system with respect to '*the improvement*' of benefits in *each* component. See Figure 4.22

Figure 4.20 **Feeding values into the datasheet**

1. People dimension	Existing System	New Sufficiency PSS
Moderation	2	4
Reasonableness	1	4
Self immunity	3	4
Average People	2.0	4.0

Figure 4.21 **Sufficiency Level of each dimension**

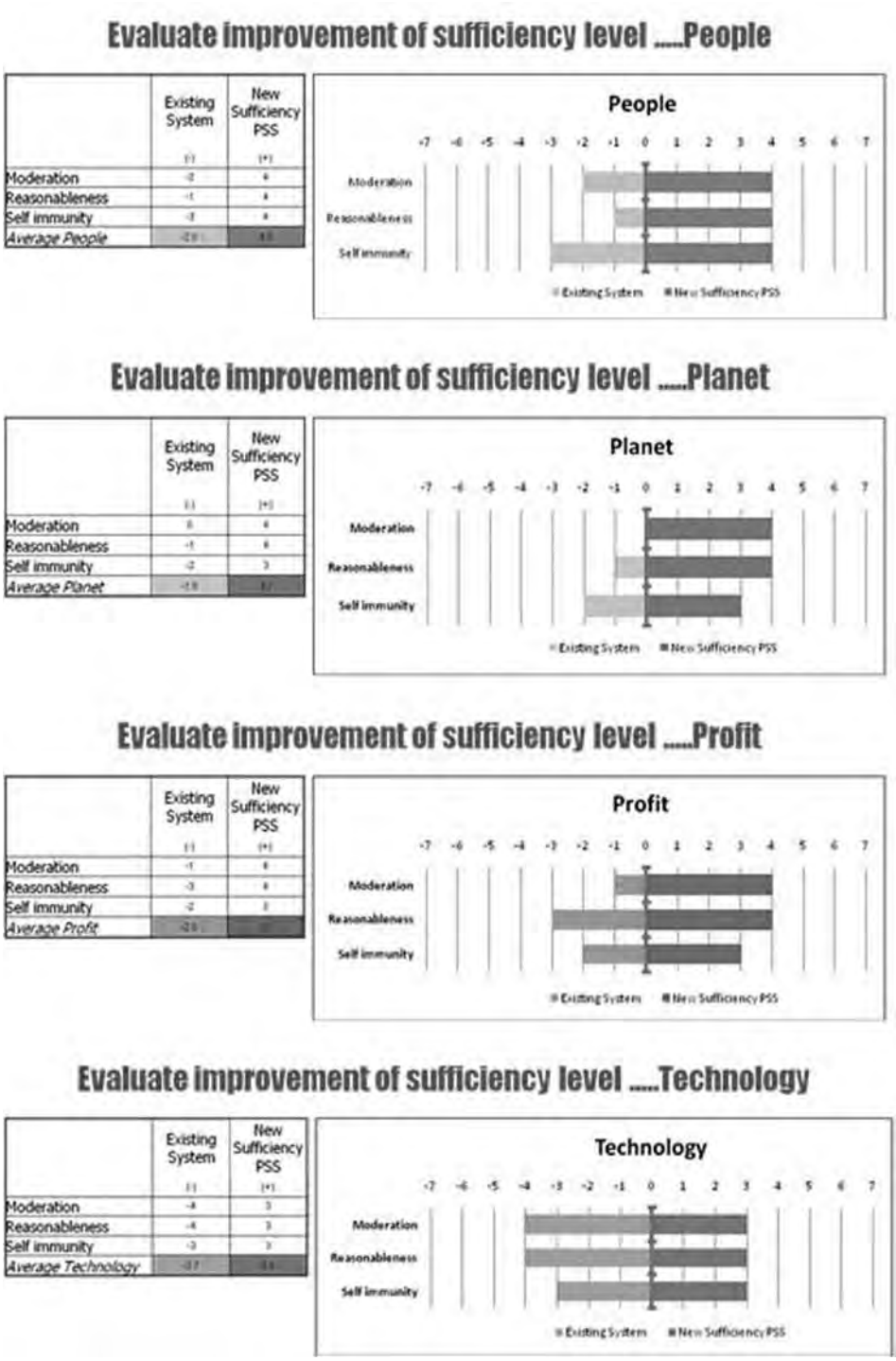
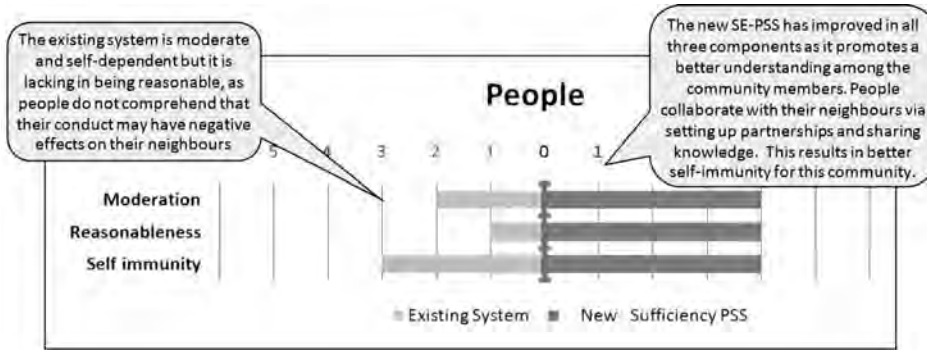


Figure 4.22 **Improvement of Sufficiency Levels (of the 'People' dimension)**



The **second aspect** is to evaluate the *Balance of the Sufficiency Level* of the overall system. To do this, the designer must:

- Feed the values from the Sufficiency Level analysis (on a scale of 0–6) of both the 'existing system' and 'new Sufficiency system' into the datasheet (using the Chart tool in Microsoft Office Excel or equivalent open source software). The values inserted into the datasheet are the average values of each component. According to the example in Figure 4.20, the average value for this step would be 2.0 [(2+1+3)/3]
- A bar chart will display four bars; each bar signifies the Sufficiency level of each dimension. Check the 'balance of the sufficiency bars **of the existing system**' in comparison to the 'balance **of the new Sufficiency system**'. See example in Figure 4.23
- Compare the result of the 'sufficiency level' of the existing and new system **both** with respect to '*the improvement*' of benefits in **each** dimension (PPP&T), and with respect to the '*equilibrium balance*' of benefits in **all** four dimensions. See Figure 4.24

Figure 4.23 **Overall Balance of Sufficiency Level (of all four dimensions)**

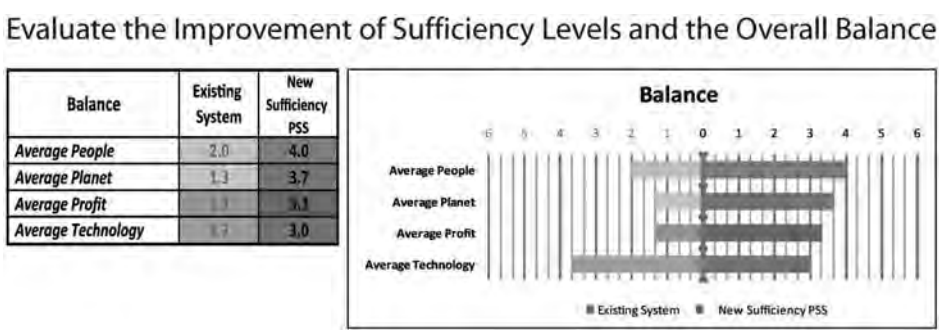
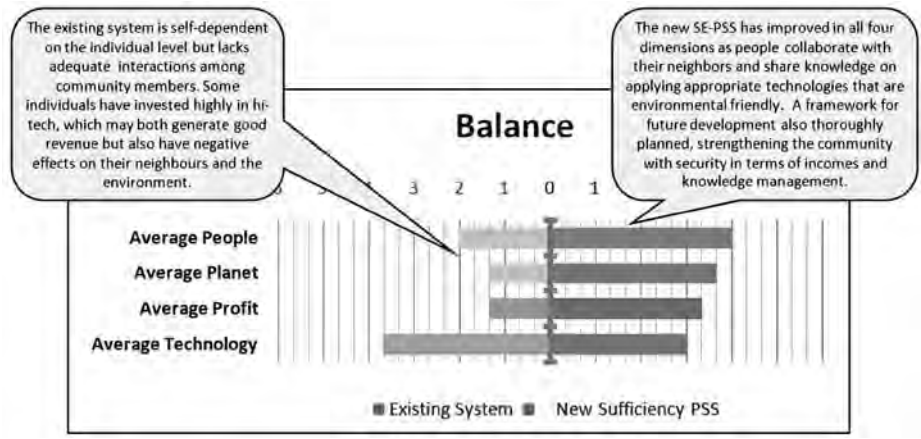


Figure 4.24 **Comparing the result of the Overall Balance**



Results

The tool supports understanding of both the current system and the new system in the form of bar charts, illustrating all important elements inherent in the Sufficiency Economy Philosophy. The focus is especially on how the new system design improves over the existing system. Improvement of benefits in each dimension is encouraged (as shown in Figure 4.21). However, the success of DSE in practice is not measured by how much we can radically reduce the frailties or increase the values that result in a more beneficial offer to users in *each dimension separately*. Instead we measure the success of any sufficiency system by *the overall balance* of the benefits we created in *all of the four dimensions*. It is therefore not absolutely necessary that there is some degree of improvement in each dimension.

A sufficient system must hence offer **both** *the improvement* of benefits in **each** dimension (PPP&T) and at the same time keep *a more balanced equilibrium of benefits* in **all** four dimensions. For example, after taking everything into consideration, sometimes a positive aspect of the existing system (such as a highly economical profit) is best reduced, for the sake of keeping the balance of the overall system as a whole and enabling the users to live harmoniously with nature and within society (or, if in exchange, so that other social benefits could be gained).

Tool availability and resources required

The Sufficiency Economy Balance Tool and instructions are available for download (from www.lens.polimi.it, 'Tools' section). The tool is based on spreadsheet software (e.g. Microsoft Excel or the equivalent in Open Office).

4.3.6 (Stakeholder) System Map[30]

Aims

The purpose of the *System Map* is to support the (co)-designing and visualisation of the system structure, indicating the actors involved and their interactions.

It is basically a graphic representation showing:

- The *socio-economic actors* involved in the system (both main and secondary)
- The different *interactions between the various actors*: material and/or product flows and those of information, money and work

The *System Map* is a representational tool that can be described as both *codified and progressive*.

It is a *codified* system in the sense that it is a 'technical drawing' of the actor system representing alternative systems in a reproducible and comparable way. In this sense, it consists of a fixed format of representation (a map), an open library of graphic elements (icons, arrows, ...) and a set of rules (layout, syntax, ...).

It is *progressive* in the sense that it is a 'formalisation-in-progress' of the solution actor map giving an increasingly accurate picture of the project as it develops. In this sense, the details of the actor system are gradually specified at each step of the designing process.

It is therefore a support tool for:

- *Designing*, because representation is a means of structuring thought and facilitating the resolution of problems
- *Co-designing*, because a standard language is used, which can therefore be shared by all the design team members or the different actors involved, supporting the strategic conversation among them
- *Communication*, because it enables unambiguous visualisation of the designed solution (as well as its evolution)

Integrating the tool into the MSDS designing process

The *System Map* is used at various stages of the designing process. In particular:

- In **Strategic analysis** it can be used to describe:
  - The production and consumption system in the scope of the design intervention

30 The tool was developed by Francois Jégou in the HiCS research project Highly Customerised Solutions, Solution-oriented design, production and delivery systems (European Research, GROWTH Programme/European 5th Framework). For further information see Jégou, Manzini and Meroni (2004); van Halen, Vezzoli and Wimmer (2005); and www.mepss.nl/index.php?p=tool&l4=W21.

  - The value chain (existing system) of the business(es) involved in the project
  - The organisation of the system (actors and roles) in a case of excellence

- In **Designing concept systems**, it can be used to:
  - Formalise the initial system ideas emerging (Figure 4.26)
  - Itemise the initial ideas emerging, identifying the main and secondary actors and their interaction flows (Figure 4.27)

- In **Designing and engineering the system**, it can be used to:
  - Itemise the configuration of the system further, defining all the actors involved and their interactions (Figure 4.28)

Figure 4.25 **Integrating the System Map into the MSDS designing process**

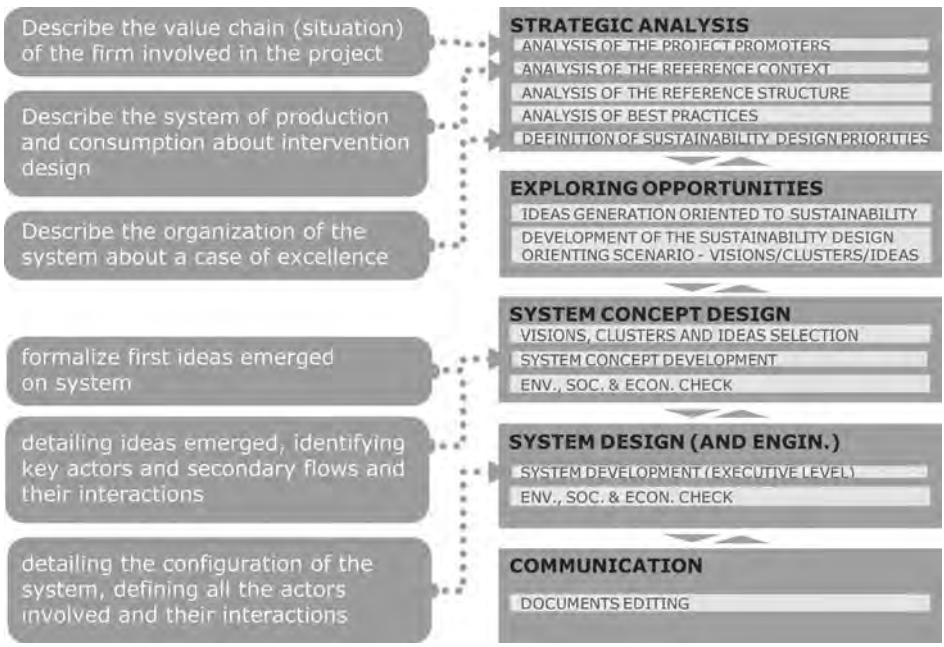


Figure 4.26 **When designing a system concept, the initial ideas (deriving from the visions and clusters of ideas developed previously) are formalised: only the main actors and flows are shown at this level**

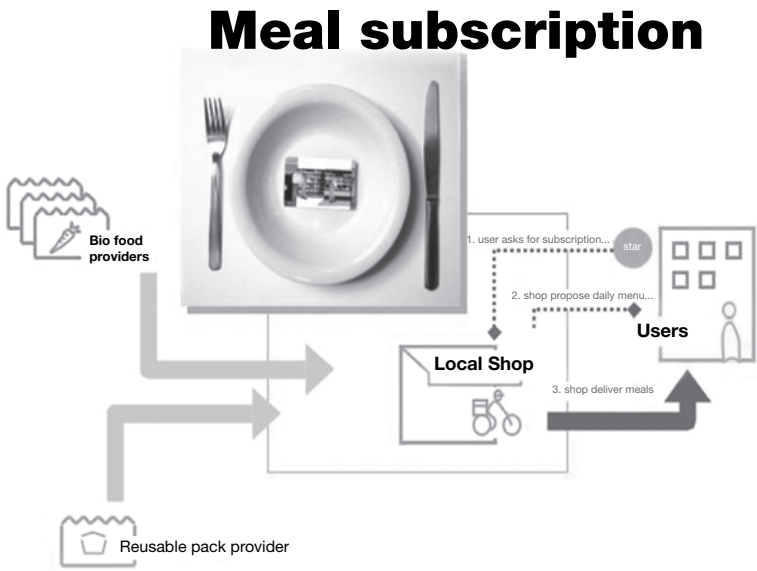
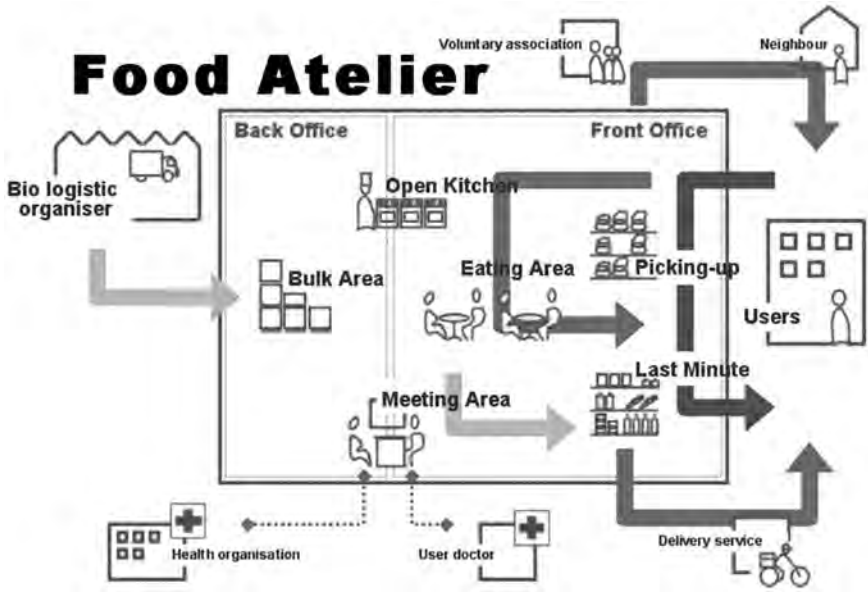


Figure 4.27 **The initial system ideas sketched out previously are now set out in detail: only the main and secondary actors are shown at this level, with their interactions**

Figure 4.28 **While designing (and engineering) the system, the system map is set out in detail, specifying all the main and secondary actors with their interaction flows. The key parts of the map are itemised in further detail. The example zooms in on the Food Atelier (a key component of the system map in Figure 4.27), specifying the component sub-elements**



How to use the tool

The tool requires the use of slideshow software (e.g. Microsoft PowerPoint, or the equivalent in Open Office). With this software it is possible to define and modify the actor map using a standardised set of purpose created icons (see Figure 4.30 to Figure 4.32).[31]

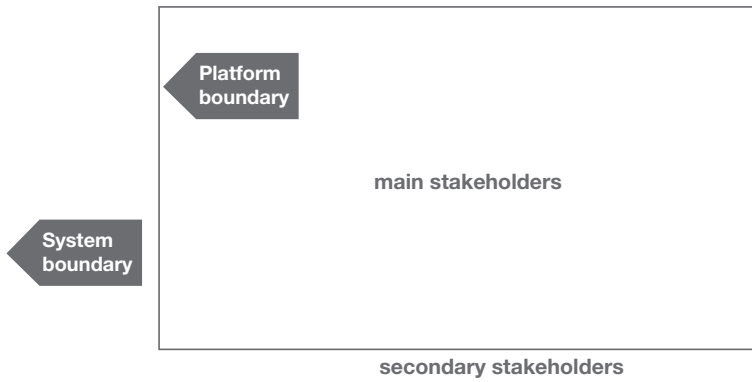
The tool is based on widely used, easy-to-use software; this facilitates the involvement of all participants in the project in the designing process and speeds up the exchange, modification and presentation of the various steps in the evolution of the solution.

The following text presents the format, library of graphic elements and the set of rules used to represent an actor map.

The *System Map* is built up on a single slide (Figure 4.29). By convention the limit of the slide is the boundary of the system, and a rectangle drawn on the slide shows the system platform boundaries: core actors performing the system are situated inside and the secondary actors outside. The latter are positioned in relation to the system life cycle: from left (beginning) to right (end).

31 It is possible to download a basic model with various icons, together with a user guide, from www.lens.polimi.it.

Figure 4.29 **System layout and platform outline**



Each actor is represented by one icon, made of three elements:

- The *structure*, which indicates the typology of actor: e.g. company, public institution, home, etc. (Figure 4.30 and Figure 4.31)
- The *characterisation*, which defines the actor activity: e.g. food producer, transporter, etc. (Figure 4.32)
- The *slogan*, which specifies the actor activity: organic food producer, supplier of logistic services, etc.)

Figure 4.30 **The structure identifies the typology of actor**

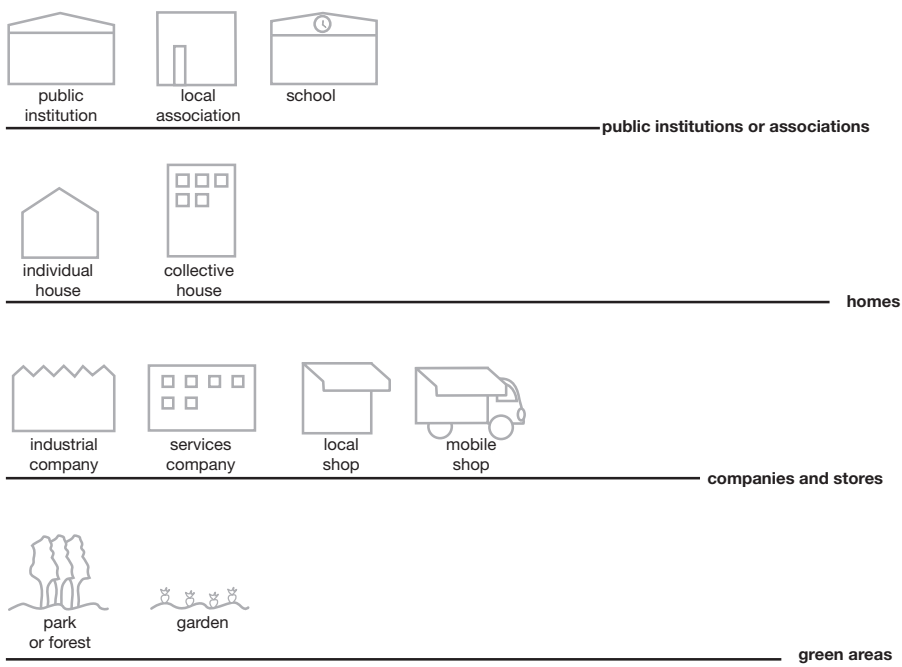
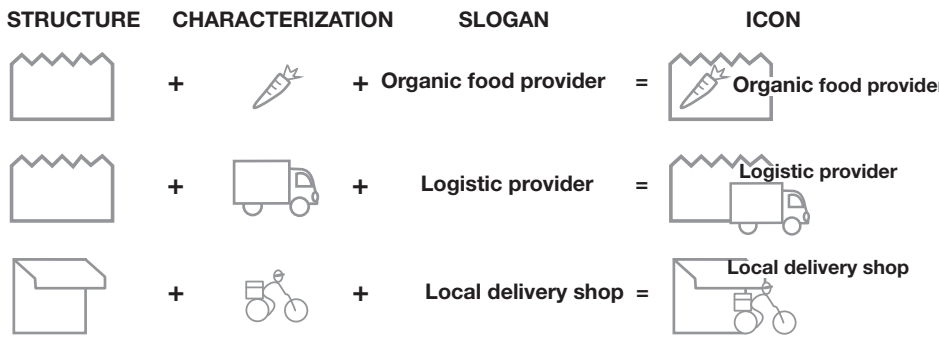


Figure 4.31 **The size of the structure indicates a main or secondary actor**

Figure 4.32 **A set of pictograms can be used to represent the actor activity**

The icon resulting from putting together these three standardised elements is able to specify an actor and differentiate him from the others on the map (Figure 4.33).

Figure 4.33 **Constructing an icon: basic structure + pictogram + slogan**

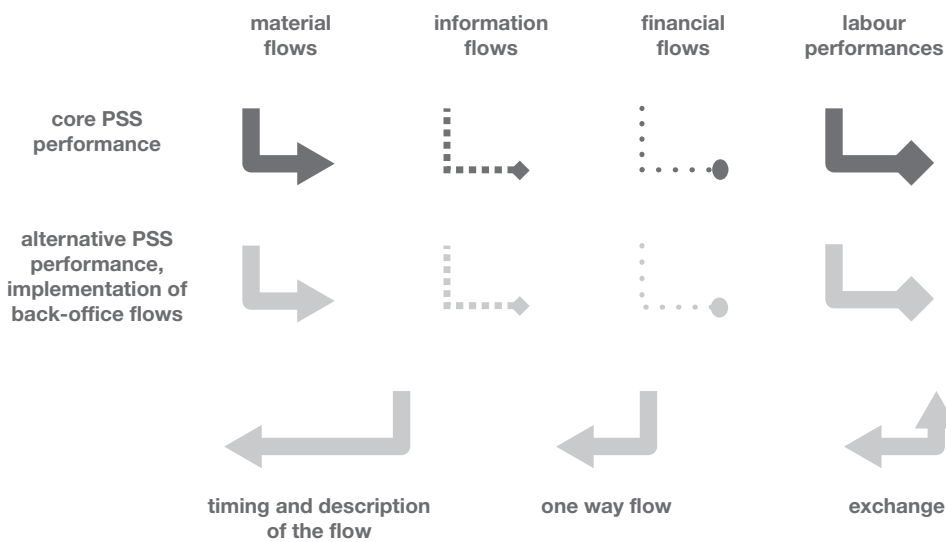


The nature of the flows between the different actors is marked by different arrows (Figure 4.34):

- The full, thick arrow indicates material flows (components, products etc.)
- The fine, square-dotted arrow indicates information flows
- The fine, round-dotted arrow indicates money flows
- The full, thick arrow with a diamond at its tip indicates work flows

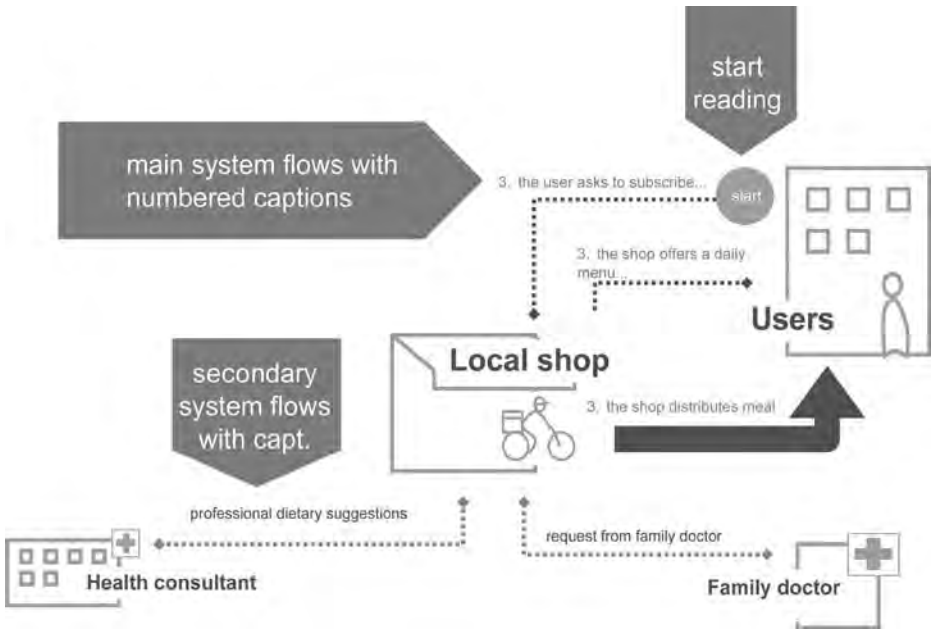
It is possible to distinguish between one-way and two-way flows. In addition the colour of the arrow indicates whether it is a primary flow (dark grey) or secondary flow (light grey).

Figure 4.34 **Different flow types: material, information, money, work**



The actors and flows are positioned during the construction of the map. In order to make the system organisation easier to understand, it is necessary to specify the various flows and define a reading order by indicating a starting point and numbering the progression of the various flows (Figure 4.35). In general only the main flows are numbered.

Figure 4.35 **Constructing a system map: various actors and flows are positioned; the flows are described and main flows numbered**



Results

The result is a map that shows the various socio-economic actors that form part of the system and their interactions (in terms of material, information, money and work flows). This map becomes more and more detailed as the project evolves.

Tool availability and resources required

The tool is based on a layout and set of standardised icons, usable with slideshow software (e.g. Microsoft PowerPoint, or the equivalent in Open Office). From this base it is possible to modify the various icons and add new ones.

The tool was developed for use by any design team member since no particular graphic skills are required.

The technical time required to set up a *System Map* is approximately 30 minutes.

4.3.7 Satisfaction system map[32]

Aims

The *Satisfaction system map* is a support tool for the generation of system ideas.

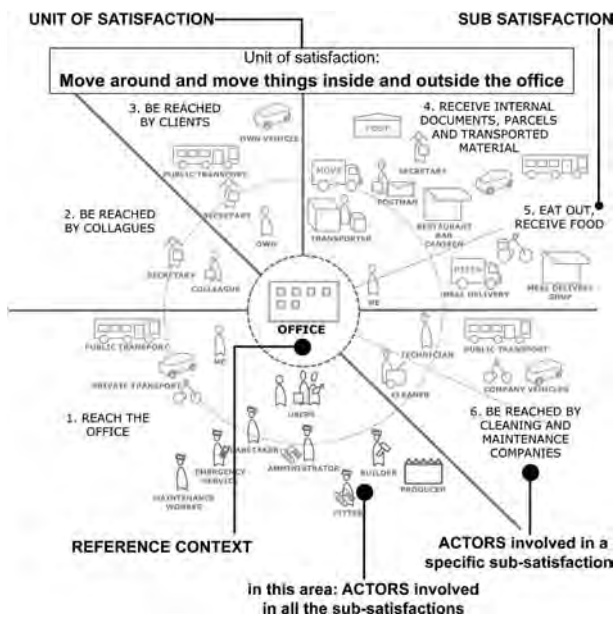
The purpose of the tool is to identify and visualise the potential socio-economic actors who could be involved in the satisfaction of a given demand for well-being. This visualisation is used during the ideation process as a stimulus to understanding which actors could potentially take part in the satisfaction system.

In other words the map is used as a stimulus to steer the generation of ideas towards solution ideas that, through the involvement of different socio-economic actors, will be able to satisfy a given demand for well-being.

It is essentially a visualisation containing the following key elements:

- Indication of the *satisfaction unit* object of design (e.g. having clothes)
- Indication of the *sub-satisfactions* that make up the basic satisfaction (e.g. having clean clothes for domestic use, having clean clothes for special ceremonies, etc.)
- Indication of the *reference context* (e.g. the home, the neighbourhood service centre, etc.)
- The *actors* who can potentially be involved in each sub-satisfaction

Figure 4.36 **Elements that make up a Satisfaction system map**



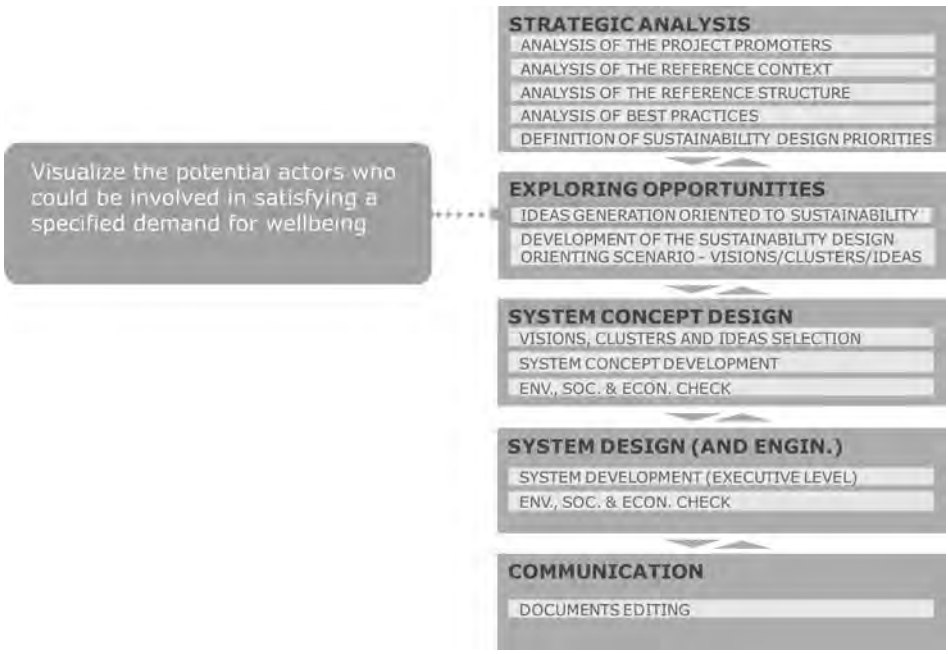
32 The tool was developed by the System Design and Innovation for Sustainability Research Unit (INDACO department, Politecnico di Milano).

Integrating the tool into the MSDS designing process

The *Satisfaction system map* can be used:

- In Exploring opportunities to:
  - Visualise succinctly the potential actors who can be involved in satisfying a given demand for well-being, and use this visualisation as a stimulus in generating ideas

Figure 4.37 **Integrating the Satisfaction system map into the MSDS designing process**



How to use the tool

The tool does not require the use of any specific software; however, to facilitate its management and modification, it is advisable to use slideshow software (e.g. Microsoft PowerPoint, or the equivalent in Open Office).[33]

It is basically a map that can be visualised on a single page/screen. The satisfaction unit to be met by the project is indicated at the top (in the example shown, this

33 It is possible to download a basic model, with its use guide, for drawing up a Satisfaction system map in the 'Tools' section of www.lens.polimi.it.

is 'to move and move things inside and outside the office'[34]); the reference context is shown in the centre (continuing with the same example, this is the office); and the various sub-satisfactions are shown radially (reaching the office, being reached by colleagues, being reached by internal documents, etc.). The actors who may potentially come into play to satisfy the given demand for well-being are shown in the areas bordering the sub-satisfactions; the actors are positioned in order of importance from the centre to the edge of the map. The actors who are generally involved in all the sub-satisfactions are positioned at the bottom. It is advisable to use the same icons as in the *System Map*.

Results

The result is a visualisation identifying, succinctly, the potential actors who can be involved in satisfying a specified need.

Tool availability and resources required

The *Satisfaction system map* can be drawn up on paper without using any software. It is however advisable to use slideshow software, in order to facilitate management and modifications.

The tool can be set up without any specific graphic skills, so it can be done by any member of the design team. When using it during brainstorming sessions, it is advisable for a facilitator to be present whose task will be to underline the salient elements on the map and use them as a design stimulus.

A *Satisfaction system map* requires the following approximate minimum technical time to set up:

- 2 hours to indicate sub-satisfactions
- 2 hours to position the actors

4.3.8 Interaction table and Interaction storyboard[35]

Aims

The purpose of the interaction table is to support the (co)designing and visualisation of a sequence of interactions between the user and the product-service system designed. The tool visualises and shows the sequence of interactions

34 The example of a *Satisfaction system map* shown here is from a project that the DIS Research Unit at the Politecnico di Milano was carrying out for KONE Elevator, with the purpose of defining eco-efficient product-service systems based on KONE elevators.

35 The tool was developed by Daniela Sangiorgi during the MEPSS European research project (Methodology for Product Service Systems) Growth Programme / European 5th Framework. For further information see Jégou, Manzini and Meroni (2004); Sangiorgi (2005); and www.mepss.nl/index.php?p=tool&l4=W22.

occurring at *front-desk* level (interaction of user with the offer system) and at *back-stage* level (interactions between the various actors in producing and delivering the offer).

Specifically the aim of the tool is (in increasing detail as the project evolves):

- To describe and visualise the sequence of *main user interactions with the offer* system
- To describe and visualise the sequence of *interactions and roles of the various actors* (involved in the production and delivery of the offer) and the user
- To describe and visualise in further detail the sequence of *interactions and roles of the various actors* (involved in the production and delivery of the offer) *and the user*

Basically the tool consists of a graphic representation showing:

- A sequence of images (accompanied by brief descriptions) showing the various interactions (of the user and other actors in the system) during the production and/or delivery of the offer
- An indication, for every interaction, of additional information: e.g. who the various actors involved are, their roles and the elements (material and non-material) required to complete it

When the aim is to show a *fluent* narration of the functioning system the interaction table is not the most effective tool. In this case the narration storyboard is recommended.

The interaction storyboard consists of a graphical representation containing in *one single row* the sequence of images plus the texts, representing (in time) the main interactions of the different stakeholders; it is in essence an abstract of the interaction table.

Integrating the tool into the MSDS designing process

The *Interaction table (storyboard)* evolves in more and more detail during the designing process:

- In **Strategic analysis,** the *Interaction table (storyboard)* may be used to:
  - Describe a case study, visualising the interaction sequence of the user with the offer system (Figure 4.39)
- In **System concept designing**, the *Interaction table (storyboard)* may be used to:
  - Describe, even partially, how the user should interact with the initial ideas of the product-service system. The representations are simple and succinct (image sequences accompanied by brief descriptions) that

should visualise the core function offered by the system and how the user interacts with it (Figure 4.40)

- Itemise the interactions of the user and other actors involved during the production and delivery of the offer. The representation becomes richer as the role of the various actors, and the (material and non-material) elements required to complete it, are specified for each interaction. Several ways to visualise can be used: it is possible to keep a single line of interaction (Figure 4.41); to have one line of interaction for the user and another for the system actors (Figure 4.42); or use a line of interaction for each actor involved (Figure 4.43)

- In **System designing (and engineering)**, the *Interaction table (storyboard)* may be used to:
  - Describe in detail all the interactions of user and actors involved in the production and delivery of the offer. Unlike the previous visualisation, a more detailed, in-depth description for every single interaction is required, in order to process all the information necessary for the solution's implementation. Each interaction is blown up in a series of interaction steps that should be carried out in order to complete the interaction itself. The role of the various system actors is itemised; to the interaction line (which separates the user actions from those of the front office) is added the visibility line (which separates the front office actions visible to the user from back office actions), and the internal interaction line (which differentiates the back office actions from the secondary support processes). Every *interaction step* is itemised separately, specifying all the components required to complete it: tools (support products, signs, etc.), interaction rules (rules that guide how the interaction should take place), expertise (which the user and actors should have in order to be able to interact), and information (required during the interaction both by the user and by the other actors)

This type of representation helps the design team to work in parallel, both on the system interface (interaction between user and front office) and on the organisation of the system itself (Figure 4.44).

Figure 4.38 **Integrating the Interaction table into the MSDS design process**

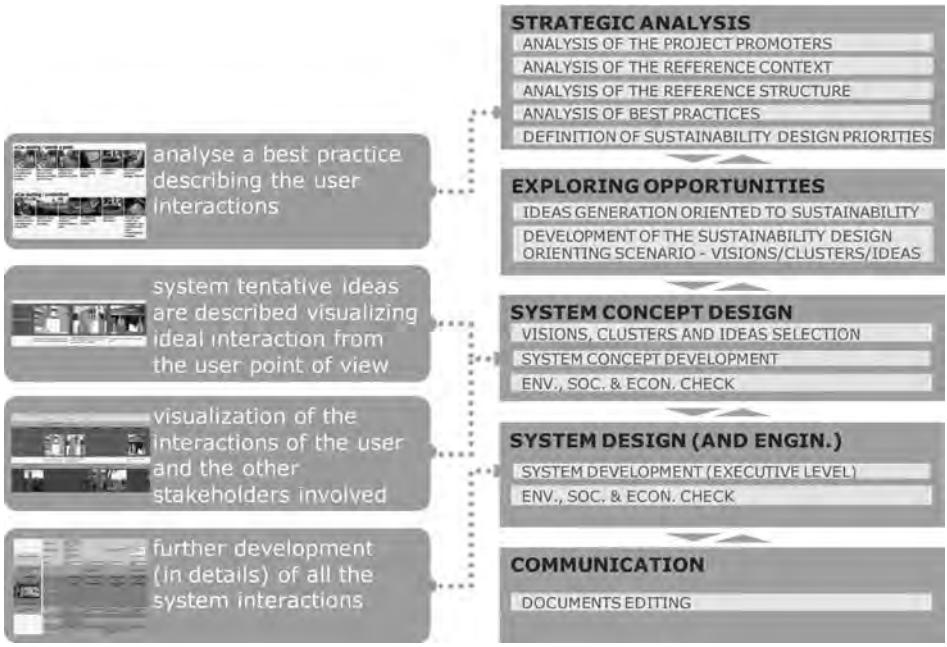


Figure 4.39 **In the example the Interaction table is used to describe the user's experience from the point of view of passenger and driver**

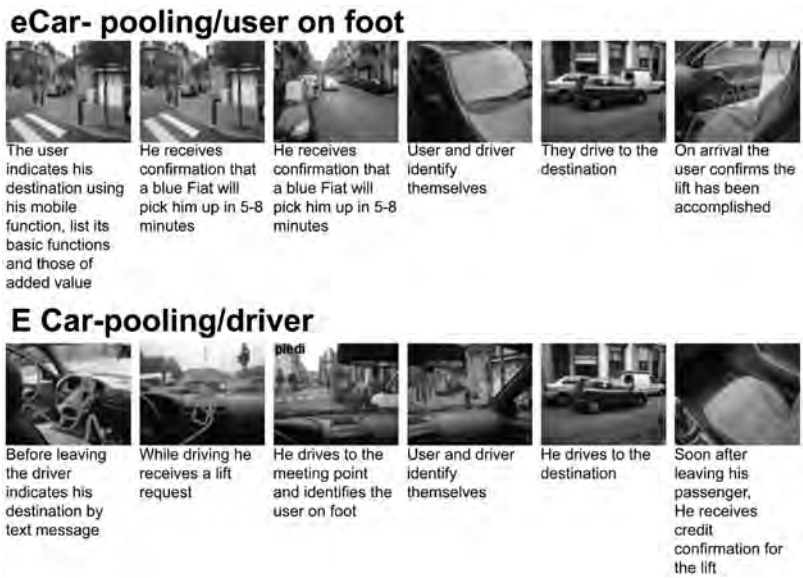


Figure 4.40 **First description of user interaction with the offer system**

Figure 4.41 **Detailed description of the user's interaction with the actors involved in the production and delivery of the offer. Visualisation with one line of interaction**

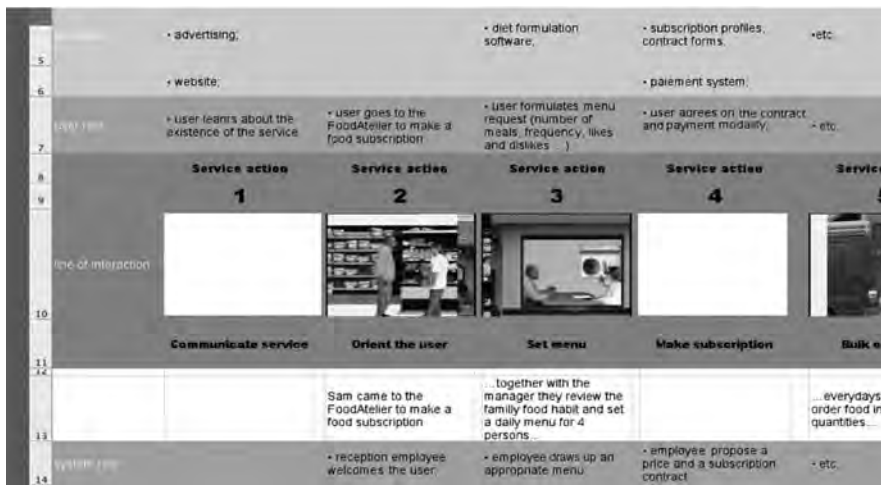


Figure 4.42 **Detailed description of the user's interaction with the actors involved in the production and delivery of the offer. Visualisation with two lines of interaction**

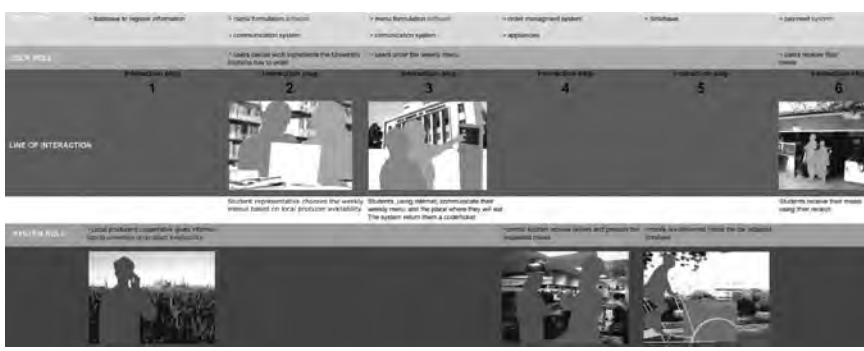


Figure 4.43 **Detailed description of the user's interaction with the actors involved in the production and delivery of the offer. Visualisation with a line of interaction for each actor**

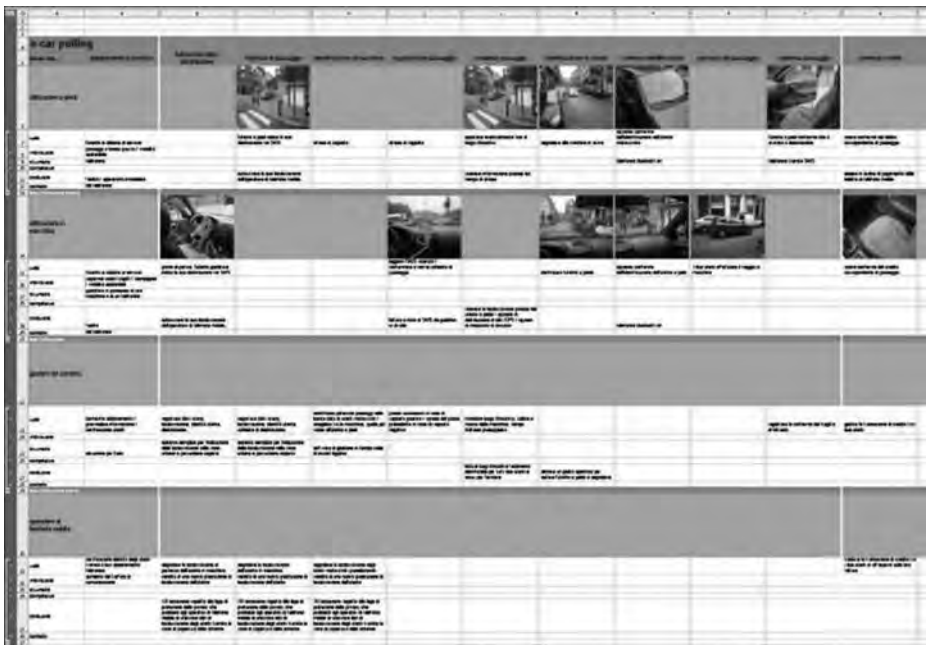
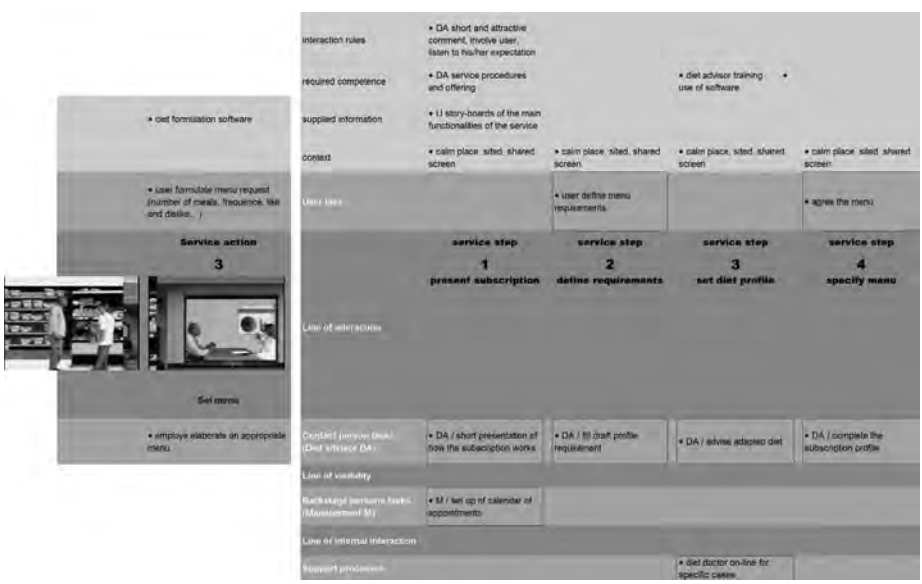


Figure 4.44 **Final version of the Interaction table with all the specifications for implementation. The diagram shows the various interaction steps that make up interaction 3**



How to use the tool

The tool requires the use of spreadsheet software (e.g. Microsoft Excel, or the equivalent in Open Office).[36] The tool is thus based on widely used, easy-to-use software; this facilitates the involvement in the designing process of all participants in the project and speeds up the exchange, modification and presentation of the various steps in the evolution of the solution.

Specifically, a spreadsheet is used to support the elaboration of an *Interaction table*. Graphic elements (interaction visualisations) and text elements (descriptions of interactions, actor roles, etc.) can be entered into the cells. It is also possible to colour the cells differently in order to e.g. differentiate interaction lines. In addition, the software enables you to hide or visualise rows and columns depending on the elements you wish to make visible.

The software also enables you to add comments to single cells, in order to facilitate teamwork and build a work-in-progress document where the various project participants can add suggestion and comments.

To visualise the interactions we recommend that:

- The image background represents the context where the action will take place
- The actors illustrated in the images are highlighted against the background
- The images contain only the necessary elements, so as to reduce semantic confusion as far as possible
- The accompanying text (usually in the third person) is a concise description of what the actor is doing
- The image sequence preserves rhythm and chronology
- Only the most significant actions are shown in the sequence (this only for the visualisations of the initial ideas of the product-service system)

Results

The result is a visualisation, made up of images and text elements, that shows the interaction sequence between the various actors who make up the system and the user, during production and delivery of the offer. This visualisation evolves in greater and greater detail during the entire designing process.

36 It is possible to download a model of the Interaction table, with its use guide, from the 'Tools' section of www.lens.polimi.it.

Tool availability and resources required

The tool is based on spreadsheet software (e.g. Microsoft Excel, or the equivalent in Open Office).

Basic graphic skills are required to create the images (using photo editing software). However, management of the *Interaction table* inside the spreadsheet can be undertaken by any member of the design team.

The time required to set up an *Interaction table* varies according to the complexity of the project and the designing stage it is used in. It is therefore difficult to assess the exact timing of its application; we can say approximately that it will require a minimum technical time of:

- 1 hour to draw up a simple *storyboard* visualising only the key interactions (initial step in the System concept designing stage)
- 8 hours to draw up a detailed *Interaction Table* specifying the interactions of the various actors (final step of the System concept designing stage)
- 2 hours for each interaction to be blown up into *interaction steps* (System designing and engineering)

4.3.9 Offering diagram[37]

Aims

The *Offering diagram* is a static representation of the system functions; it can be used both as a design and a visualisation tool. The tool is useful to the design team for defining in ever-increasing detail the functions that the system delivers to the user.

It is basically a graphic representation, made up of images and text elements, showing (in ever greater detail as the design process evolves):

- The *core function*, i.e. the function that characterises the offer (e.g. customised meal delivery)
- The *basic functions*, i.e. the functions required for the execution of the core function (e.g. ordering, paying, etc.)
- The *added value functions*, i.e. functions associated with the core function able to enrich and increase its value (e.g. dietary advice)
- The *sub-functions*, which describe the way in which the functions will be delivered (e.g. the function 'dietary advice' can be itemised in 'online dietary advice', 'dietary information on products' etc.)

37 The tool was developed by Francois Jégou during the MEPSS European research project (Methodology for Product Service Systems) Growth Programme / European 5th Framework. For further information see: van Halen, Vezzoli and Wimmer (2005), and www.mepss.nl/index.php?p=tool&l4=W23. The descriptive text here is taken from: www.mepss.nl/index.php?p=tool&l4=W23.

Integrating the tool into the MSDS designing process

The *Offering diagram* becomes increasingly detailed throughout the entire designing process:

- When **Exploring opportunities**, the *Offering diagram* can be used to:
  - Describe the various clusters of ideas that make up the scenario. These idea clusters can be associated with a particular core function. It may be useful to give these clusters a title, a brief to-the-point description and propose a characterising image
- When **System concept designing**, the *Offering diagram* may be used to:
  - Itemise the basic and added value functions, starting with the core function. The system concept is outlined in this stage, so the offer system must be developed. In this sense the *Offering diagram* is both a design tool supporting designers in itemising their offer system and a visualisation tool that facilitates communication in the team and between different actors (Figure 4.46)
- When **Designing (and engineering) the system**, the *Offering diagram* may be used to:
  - Describe and list all the single functions and relative sub-functions required to implement the designed solution. This means that every basic function and every added value function must be itemised in sub-function clusters (which describe and specify how the functions will be delivered) (Figure 4.47)

Figure 4.45 **Integrating the Offering diagram into the MSDS designing process**

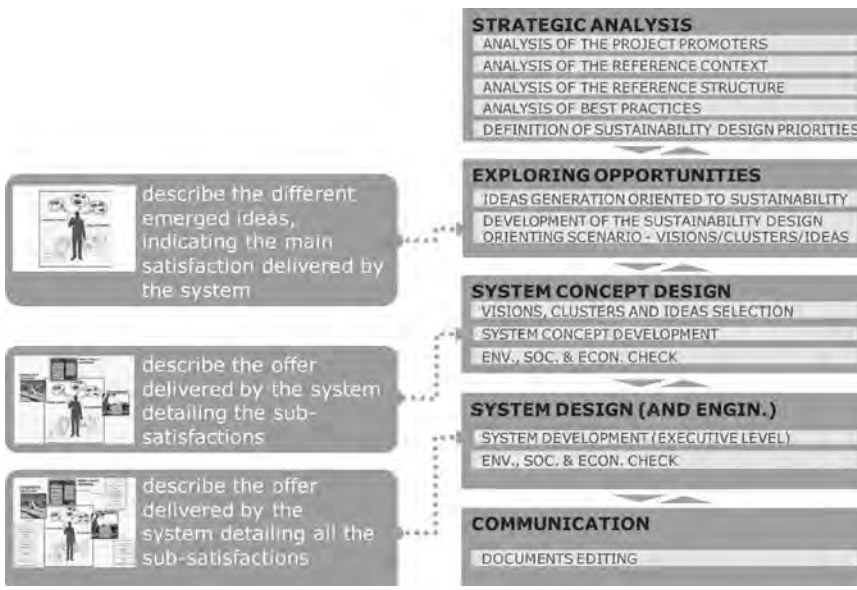
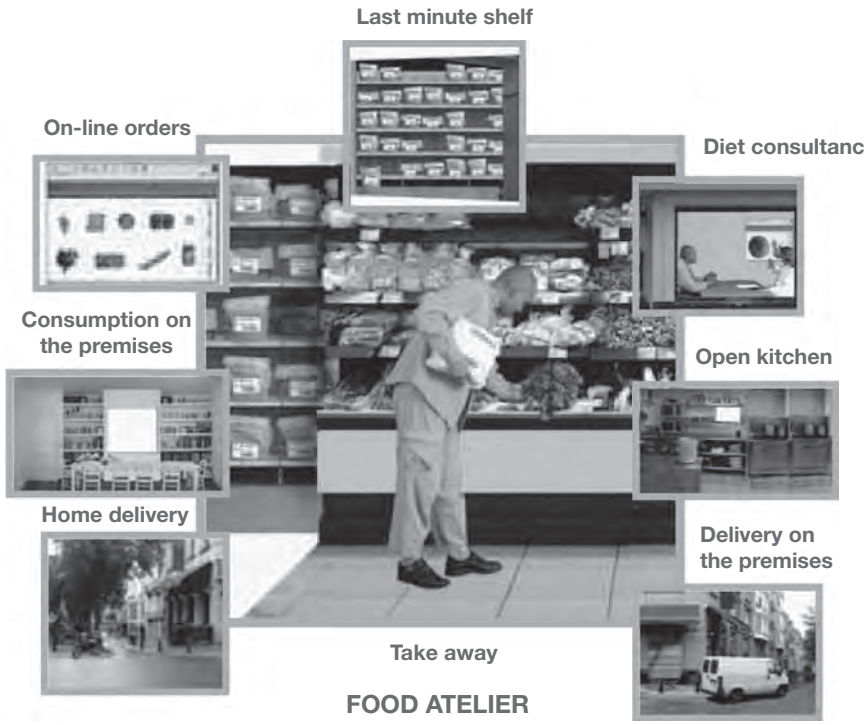


Figure 4.46 **During the system concept designing stage the Offering diagram helps evolve the basic functions, and those of added value are defined around the main functions**

Source: van Halen, Vezzoli and Wimmer (2005), with English translation



How to use the tool

The tool does not require any specific software; the *Offering diagram* can be drawn directly on paper. However, if the tool is used for communication purposes it is advisable to use graphic image processing software and slideshow software to draw up the images.

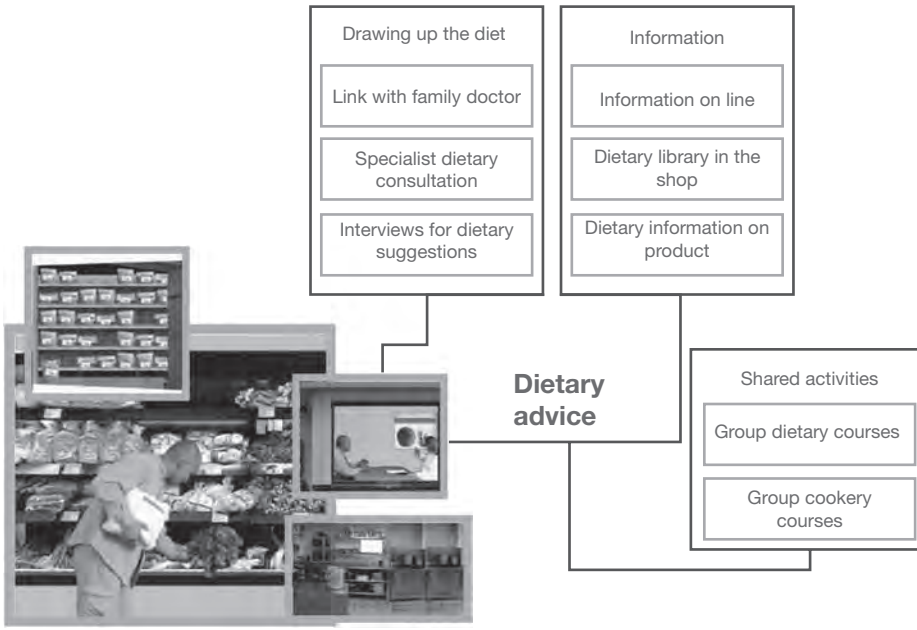
The *Offering diagram* is drawn up positioning the core function (represented by a significant image, a title and possibly an accompanying text) at the centre of the layout.

The basic and added value functions are positioned around the core function; these too can consist of an image accompanied by an explanatory text. You can also play with the size of these images to communicate whether the function is basic (larger) or added value (smaller).

The sub-functions are positioned, in text form, around their relative functions.

Figure 4.47 **During the system designing stage the Offering diagram evolves further: every single function is itemised in sub-functions**

Source: van Halen, Vezzoli and Wimmer (2005), with English translation



Results

The result is a diagram that visualises the functions (core, basic and added value) and sub-functions offered by the systems. There may be different diagrams according to the various system concepts developed.

Tool availability and required resources

The *Offering diagram* can be drawn directly on paper. However, it is preferable to use slideshow software to draw up the diagram, together with graphic image processing software. In this way it can more easily be modified by the various members of the design team. Basic graphic skills are required to create the images (using photo editing software).

The time required to create an *Offering diagram* varies with the complexity of the design project. However, we can approximately estimate a minimum technical time of:

- 1 hour to create a simple *Offering diagram* showing only the core function
- 2 to 3 hours to add basic and added value functions to the diagram
- 2 to 3 hours to add all the sub-functions

4.3.10 Polarities diagram[38]

Aims

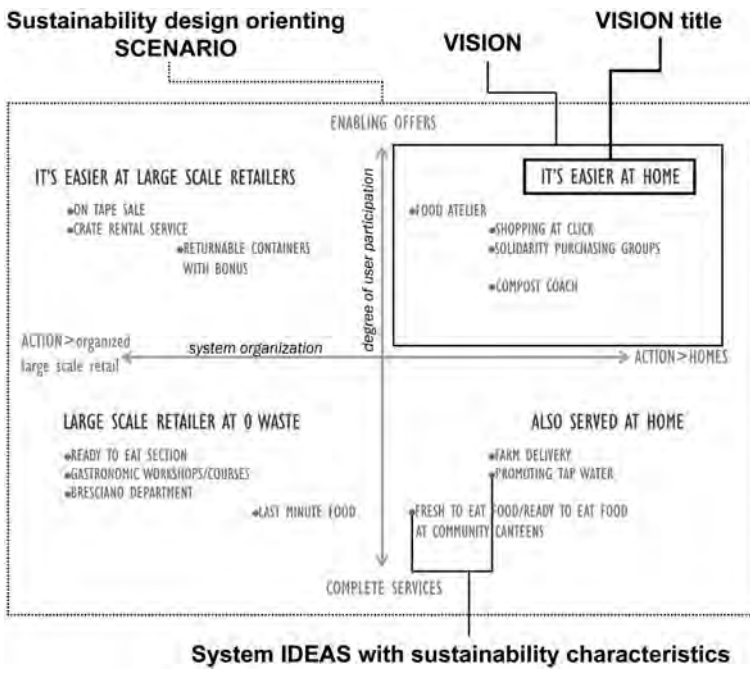
The *Polarities diagram* was developed to 'explore' the possible and promising directions in which current systems may evolve. In other words it is a tool that supports the definition of how the existing system can be reshaped, starting with specified design choices: it supports the generation of ideas and facilitates their organisation and presentation. It is used, in particular, at the start of the designing process to define and visualise what we call a *sustainability design-orienting scenario*, i.e. the set of possible and promising reconfigurations that a system may take.

In practice it is a diagram constructed by crossing two polarities (Figure 4.48); one polarity shows a possible variation in the product-service system in two opposite directions (e.g. the user involvement may be low, and therefore on one side we have *full-service offers*, or high, and so on the other side we have *enabling solutions*).

On the one hand the tool facilitates the positioning and organisation of the ideas in the diagram; on the other it stimulates the generation of further ideas, e.g. by asking what would happen if an idea were moved from one quadrant to another.

Figure 4.48 **Example of polarity diagram showing its component elements**

Source: images processed by Vezzoli, Orbetegli and Ceschin 2006



38 The tool was developed during the MEPSS research project, Methodology for Product Service Systems (Growth Programme / European 5th Framework), with the aim of supporting scenario building. For further information see van Halen, Vezzoli and Wimmer (2005), and www.mepss.nl/index.php?p=tool&l4=W19.

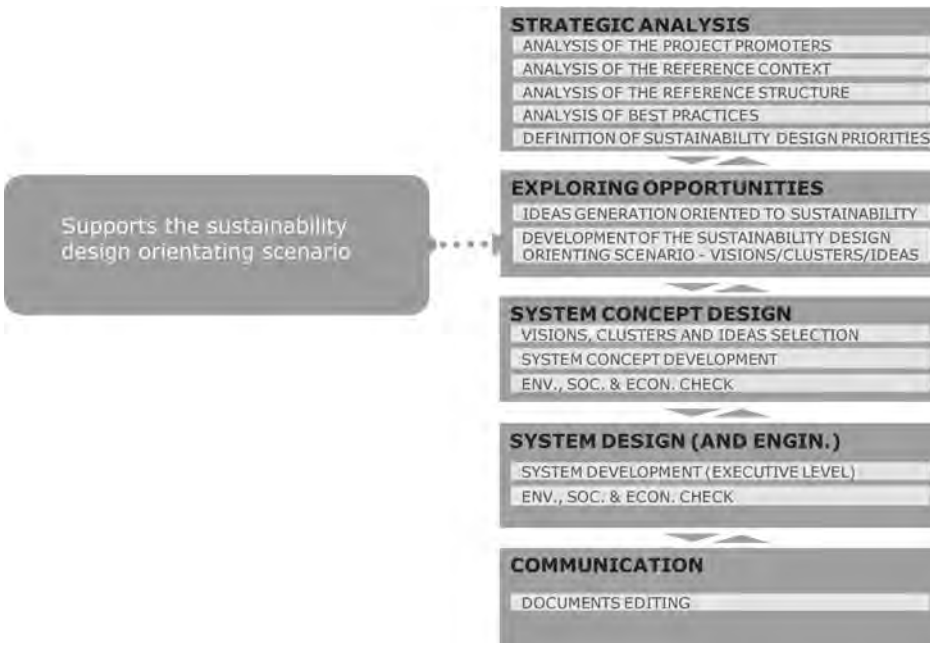
Integrating the tool into the MSDS designing process

The Polarity diagram is used:

- In **Exploring opportunities**, to support the building of *a sustainability design-orienting scenario*, in other words the set of possible configurations that the new product-service system could take

The scenario in turn includes four *visions* (one per quadrant), schematic descriptions of how a context could evolve if certain design choices were adopted (Figure 4.52). Each vision is described in more detail by the set of ideas positioned inside the relative quadrant; for the sake of organisation and communication these ideas can be regrouped in clusters, i.e. groupings of ideas sharing basic characteristics (Figure 4.53). It is important to stress that polarity diagrams are used in the MSDS method to support the organisation of potentially sustainable ideas generated through the *SDO toolkit* (see Section 4.3.1—SDO toolkit). For this reason the resulting scenarios and visions are considered to be sustainability-oriented scenarios and visions.

Figure 4.49 **Integrating the Polarities diagram into the MSDS design process**



How to use the tool

The tool does not require any specific software; it can be drawn up on paper or in digital form (e.g. using slideshow software).[39] Four steps can be identified: *Generating ideas, Identifying promising polarity diagrams and polarising ideas, Defining visions, and Defining clusters of ideas.*

Generating ideas

Sustainability-oriented ideas are generated in brainstorming sessions. In the MSDS methodology this process is supported and facilitated by, for example:

- Sustainable idea generating tables (*SDO toolkit*, see 4.3.1—SDO toolkit)
- A *Satisfaction system map*, i.e. a representation visualising the different socio-economic actors who can potentially be involved in satisfying a specified demand for well-being (see 4.3.7—Satisfaction system map)
- Analysis of cases of excellence

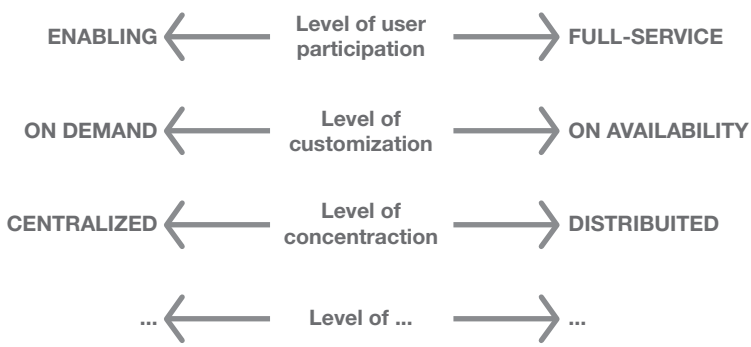
The various ideas can be described in text (title, key words, extended description) and/or visual elements (images, sketches, etc.).

Identifying promising polarity diagrams and polarising ideas

In this step the *Polarities diagram* is drawn up in such a way that the emerging ideas can be spread over all the quadrants.

When drawing up the diagram it is possible to: 1) choose from various already defined polarities; and 2) define them again according to the needs of the project.

Figure 4.50 **Examples of polarity that can be used in drawing up polarity diagrams**

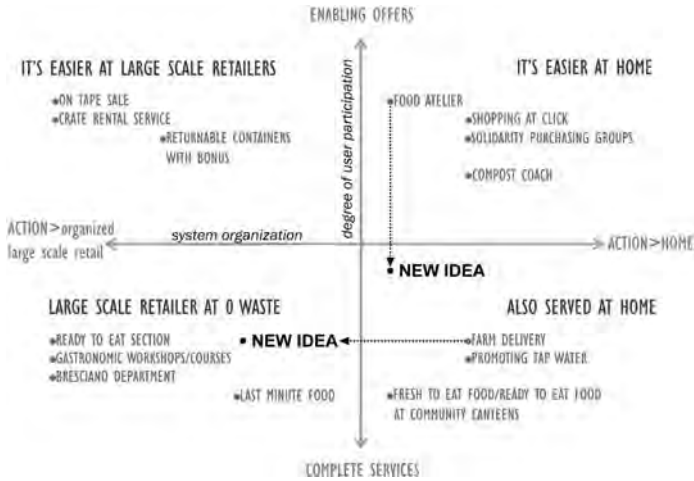


39 It is possible to download a basic model for creating Polarity diagrams, and a use guide, from www.lens.polimi.it, the 'Tools' section.

At this point it is possible to position the ideas on the diagram. It must be stressed that this operation does not only aim to organise and present ideas, but also to stimulate the generation of further ideas. It is possible to shift ideas from one quadrant to another to potentially bring out new ideas.

Figure 4.51 **Composition of polarity diagram, idea positioning, and generation of further ideas**

Source: reworked image from Vezzoli, Orbetegli and Ceschin 2006



Defining visions

Once all the ideas have been positioned it becomes possible to define *visions*, which, as we said, represent schematic descriptions of how the context could evolve if certain design choices were adopted. Each vision (one per quadrant) will represent a potential, promising orientation on which the system could evolve.

Usually each vision is described by means of a title and a more extensive description.

Definition of idea clusters

Parallel to the definition of visions it is also possible to cluster emerging ideas, i.e. create groups of ideas with shared characteristics. This is particularly advisable when a very large number of ideas have to be managed, to improve their organisation and presentation.

The amalgamation of several clusters of ideas (also from different quadrants) constitutes the starting point for the generation of one or more system concepts.

Figure 4.52 **Definition of the visions that make up the scenario**

Source: reworked image from Vezzoli, Orbetegli and Ceschin 2006

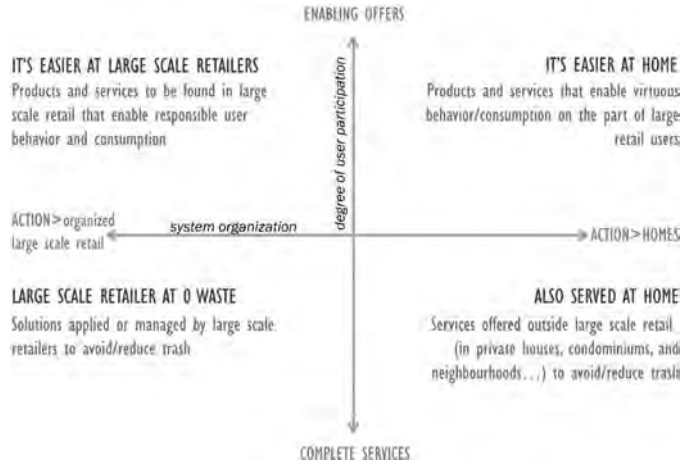
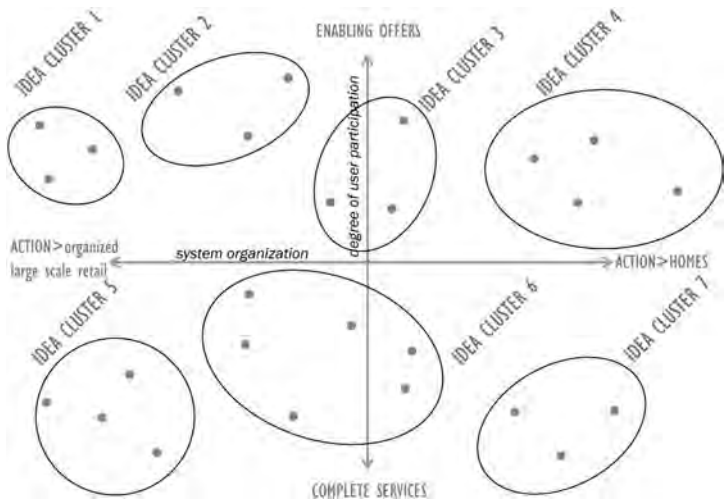


Figure 4.53 **Definition of clusters of ideas**

Source: reworked image from Vezzoli, Orbetegli and Ceschin 2006



In short, the process just described starts with idea generation and leads to the definition of the *Polarities diagram* and relative visions. In reality it is also possible to proceed in the opposite direction, and so:

- Define a *Polarities diagram* (starting with existing polarities or create them ad hoc)
- Define *visions* by describing the four emerging quadrants
- Use the *Polarities diagram* and relative *visions* to stimulate idea generation

Results

The result is a diagram describing a sustainability design-orienting scenario, with relative visions and idea clusters.

Tool availability and resources required

The diagram can be drawn up on paper. However, it is advisable to use slideshow software, in order to facilitate integration and modification.

Use of the tool does not require any particular graphic skills, so it can be managed by any member of the design team.

The use of *Polarities diagrams* accompanies all activities from polarising ideas to defining visions and clusters of ideas. The time it requires therefore varies according to the particular project. However we can approximately estimate a minimum technical time of:

- 30 minutes to define polarities and draw up the diagram
- 2 hours to position the ideas and generate further ideas
- 2 hours to define visions
- 2 hours to define idea clusters

4.3.11 Solution element brief[40]

Aims

The *Solution element brief* is a (co)designing and visualisation tool. Its purpose is to describe the elements (material and non-material) required by the system and which of the system actors must design/produce/deliver these elements. The tool basically helps to define the roles of the individual actors in developing and delivering the solution.

It is basically a graphic representation, structured as a two-way table, where:

- The material (products, equipment, etc.) and non-material (information, services, etc.) *elements* necessary to implement the solution are visualised along the horizontal axis. These elements are usually represented by pictograms
- The *actors* involved in the system are visualised along the vertical axis
- By crossing the *elements* with the *actors* the contribution made by the single actors in designing, producing and delivering the various elements is visualised

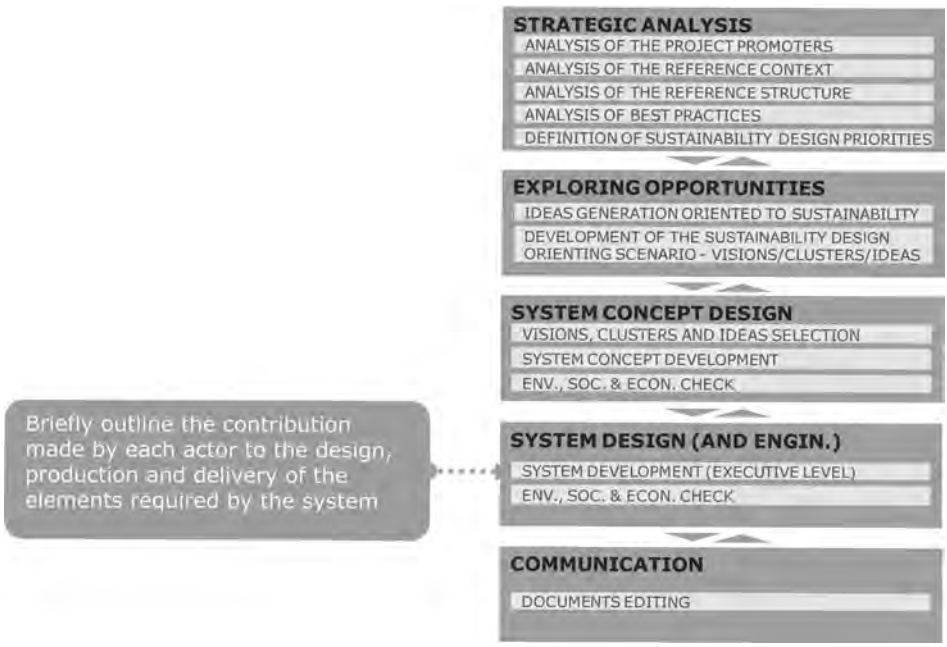
40 The tool was developed during the HiCS research project Highly Customerised Solutions, Solution-oriented design, production and delivery systems (European Research, GROWTH Programme / European 5th Framework). For further information see: Jégou, Manzini and Meroni (2004).

Integrating the tool into the MSDS designing process

The *Solution element brief* is mainly used:

- In **Designing (and engineering) the system**, to define succinctly and effectively the contribution made by each actor in the system to the designing, production and delivery of the single elements

Figure 4.54 **Integrating the Solution element brief into the MSDS designing process**



How to use the tool

The tool does not require the use of any particular software; however, to manage the various graphic elements more effectively it is advisable to use spreadsheet software (e.g. Microsoft Excel or the equivalent in Open Office).[41]

Widely used, easy-to-use software facilitates the involvement of all project participants in the designing process and speeds up the exchange, modification and presentation of the various steps in the evolution of the solution.

It is possible to enter various graphic and textual elements into the cells of the spreadsheet.

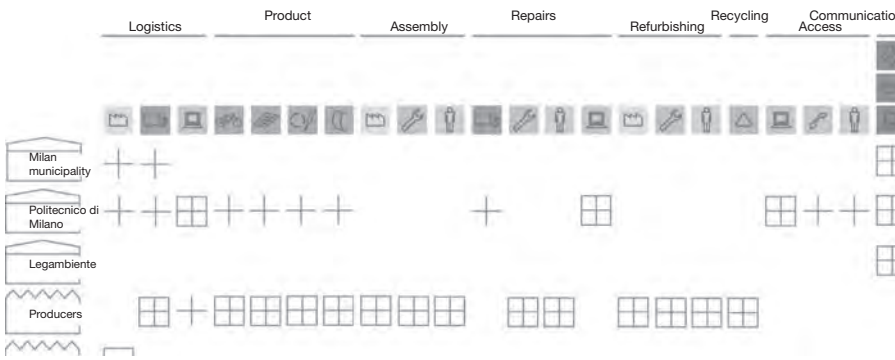
The parts that make up the visualisation are:

41 It is possible to download a basic model for creating a Solution element brief, and a use guide, from www.lens.polimi.it, the 'Tools' section.

- The *functions* required for the system to work
- The *elements* that make up the single functions (these can be represented by pictogram or, more simply, by descriptive texts)
- The *actors* who are part of the system (these can be represented by a .jpg created from the icons used in the *System Map*, or simply their names can be used)
- The *roles* that the different actors play in designing, producing and delivering the various elements (these can be represented by symbols, as shown in the key)

Figure 4.55 **Example of Solution Element Brief. At the top we can see the elements necessary for implementation of the solution (individual elements are described in a key). Each element is associated with various actors in the system: a cross indicates that the actor will contribute to designing that particular element; a square indicates that the actor will produce or deliver the element; a combination of cross and square indicates that the actor will contribute to both designing and production and delivery**

Source: Ceschin 2006



Results

The result is a graphic representation structured as a two-way table, showing the (material and non-material) elements required for implementation of the system and the roles of the various actors in designing, producing and delivering each element.

Availability of tools and resources required

Image processing software is required to create the icons. The use of spreadsheet software is advisable for drawing up the *Solution element brief*, so as to facilitate integration and modification.

Basic graphic skills are required to create the images (using photo editing software). However, management of the *Solution element brief* inside the spreadsheet software can be undertaken by any member of the design team.

The time required to draw up a *Solution element brief* varies according to the complexity of the project. However we can approximately estimate a minimum technical time of:

- 4 hours to create the icons (to save time, icons can be replaced by text descriptions)
- 4 hours to process the Solution element brief

4.3.12 Stakeholder motivation matrix[42]

Aims

The *Stakeholder motivation matrix* is a (co)designing and visualisation tool. Its purpose is to represent the solution from the point of view of the *motivations* of the single actors for taking part in the system. It is basically a tool for defining the role and the contributions each actor can supply to the general partnership, and to each of the other actors.

It is a two-way table where the various actors are positioned on both sides; by crossing the various actors it is possible to see, for each actor, what are (or could be):

- The *motivations* for taking part in the system
- The *contribution* made to the partnership in general, and to other single actors in particular
- The *contribution* received from the partnership and from other single stakeholders
- The potential areas of *synergy* or *conflict* with the various actors

42 The tool was developed in the HiCS research project Highly Customerised Solutions, Solution-oriented design, production and delivery systems (European Research, GROWTH Programme / European 5th Framework). For further information see: Jégou, Manzini and Meroni (2004). The description in this section was taken from: Jégou, Manzini and Meroni (2004).

Integrating the tool into the MSDS designing process

The *Stakeholder motivation matrix* can be used:

- In **System concept designing**. In this case the project proposers can use the tool first of all to define their own motivations, potential contributions and expected benefits to be derived from being part of the system. It can also be used to describe hypothetical partners to identify and involve in future (Figure 4.57)
- In **Designing (and engineering) the system**. The *Stakeholder motivation matrix* evolves together with the designing process: the hypothetical actors (previously identified) are replaced by real actors; their intentions, contributions and expected benefits are redefined and itemised; and the synergies between the actors are reinforced and any conflicts reduced and resolved (Figure 4.58)

Figure 4.56 **Integrating the Stakeholder motivation matrix into the MSDS designing process**

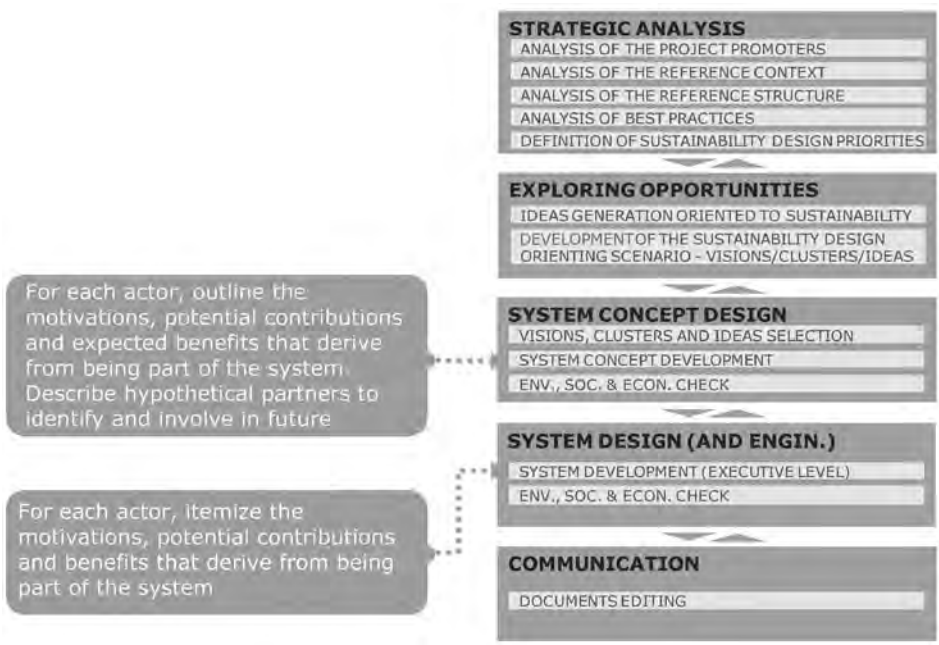


Figure 4.57 **Using the Stakeholder motivation matrix in the System concept design stage**

Source: reworked image from Ceschin 2006

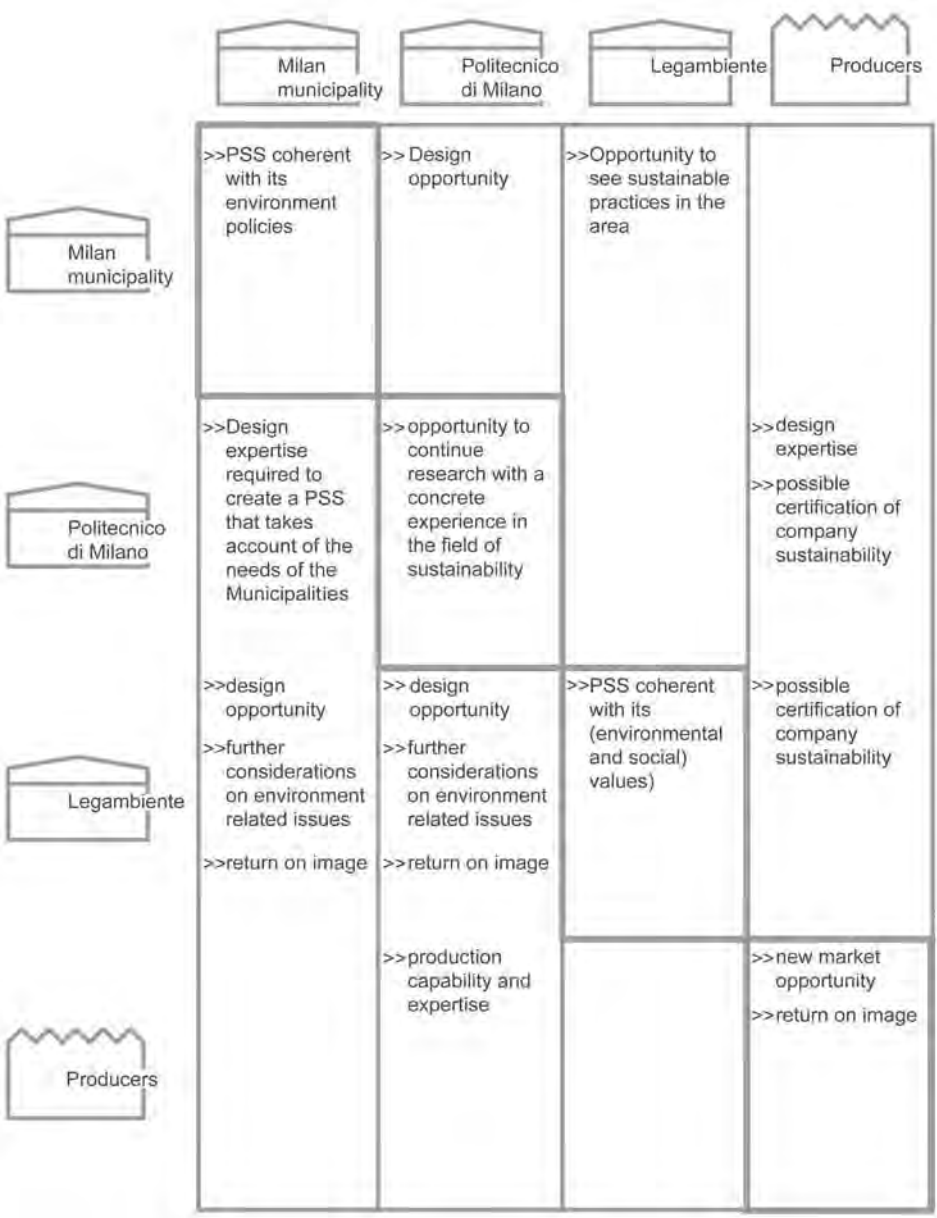
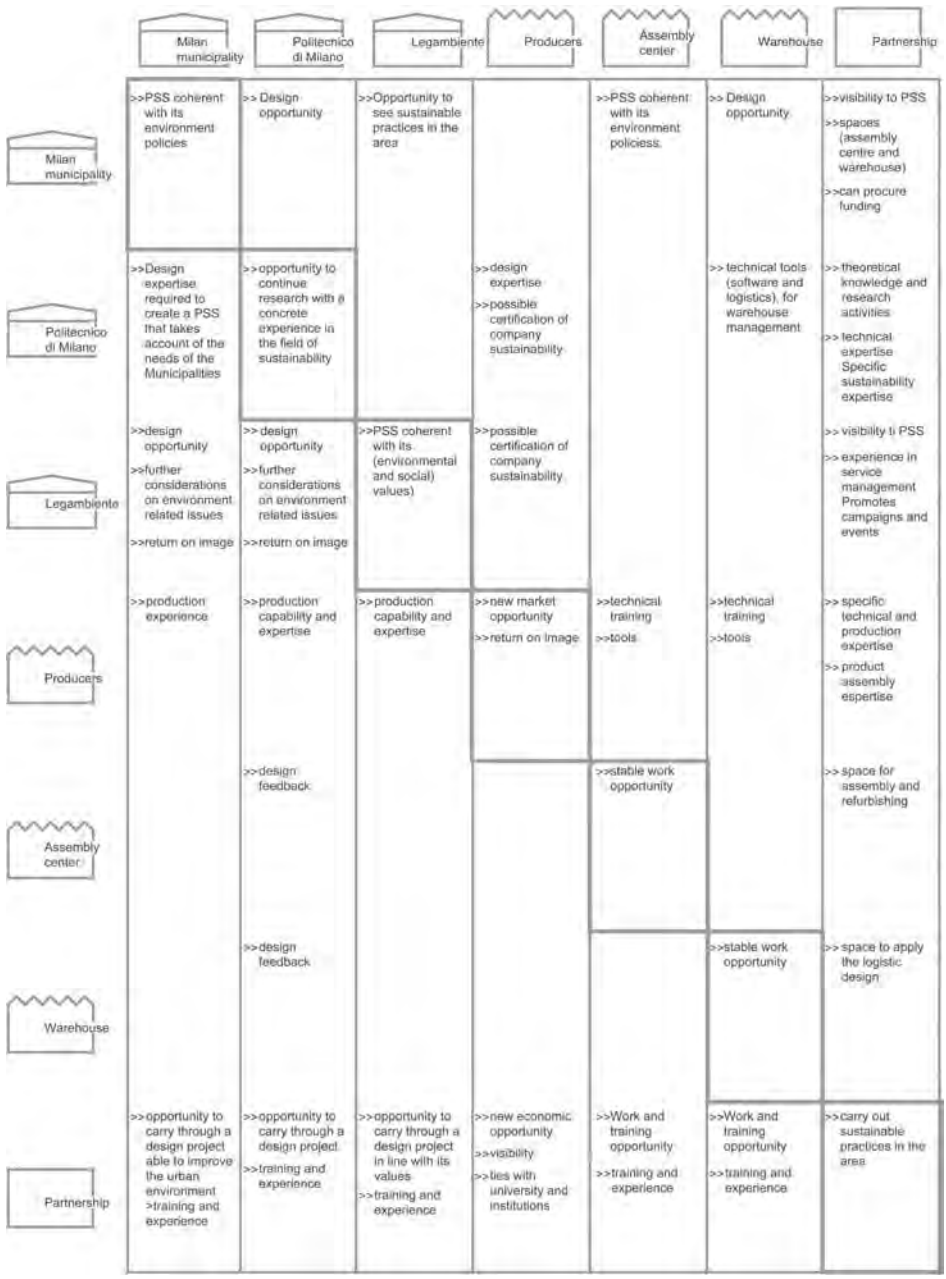


Figure 4.58 **Use of Stakeholder motivation matrix in the System designing and engineering stage**

Source: reworked image from Ceschin 2006



How to use the tool

The tool does not require the use of any particular software; however, to manage the various graphic elements more effectively it is advisable to use spreadsheet software (e.g. Microsoft Excel or the equivalent in Open Office).[43]

The widely used, easy-to-use software facilitates the involvement of all project participants in the designing process and speeds up the exchange, modification and presentation of the various steps of the tool.

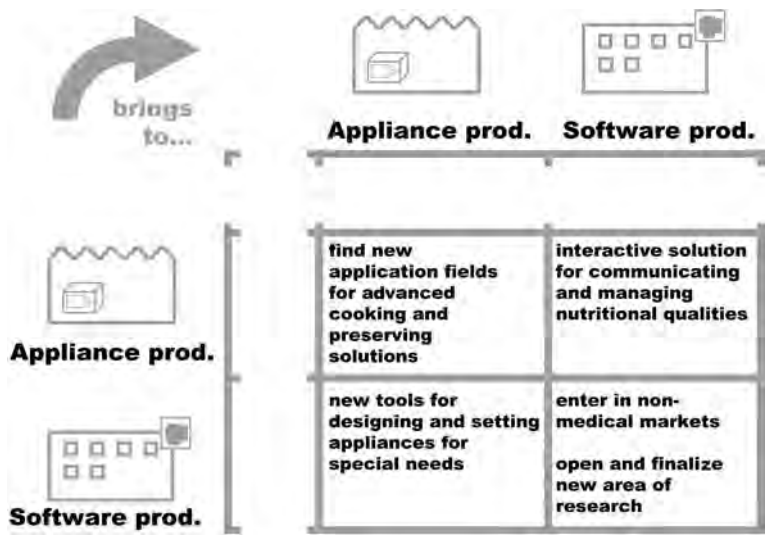
It is possible to enter various graphic and textual elements into the cells of the spreadsheet.

The parts that make up the visualisation are:

- The *actors*, positioned on both sides of the two-way table (these can be represented by a .jpg created from the icons used on the *System Map*, or simply their names can be used)
- The *motivations*, *contributions* and *expected benefits*, to be entered for each pair of actors

The table is read by crossing the actors positioned on the left side with those positioned at the top.

Figure 4.59 **The elements that make up the Stakeholder motivation matrix and how to read it**



43 It is possible to download a basic model for creating a Stakeholder motivation matrix, and a use guide, from www.lens.polimi.it, the 'Tools' section.

Results

The result is a graphic visualisation structured as a two-way table, where for each actor in the system, the motivations, contributions, expected benefits and potential conflicts and synergies deriving from being part of the system are described.

Tool availability and resources required

Image processing software is required to create the icons (the icons can be created from those used on the *System Map*). The use of spreadsheet software is advisable for drawing up the *Stakeholder motivation matrix,* so as to facilitate integration and modification.

Basic graphic skills are required to create the images (using photo editing software). However, management of the *Stakeholder motivation matrix* inside the spreadsheet software can be undertaken by any member of the design team.

The time required to draw up a *Stakeholder motivation matrix* varies according to the complexity of the project. However we can approximately estimate a minimum technical time of:

- 2 hours to draw up an initial version of the matrix (with main actors only)
- 2 hours to update the matrix with the secondary actors

4.3.13 miniDOC[44]

Aims

Audiovisual tools have great potential to promote dialogue through the practice of storytelling. MiniDOC is a video tool able to support internal dialogue among decision-makers involved in a system co-design process.

In a short length of time (about five minutes) the tool visualises the key aspects that emerge from analysis work by involving:

- Identification of case studies and best practices
- Video interviews with stakeholders
- Research on historically and contemporary iconographic repertoires useful to reconstruct memory and stimulate imagination

The specific purpose of the tool is to:

- Explore and map the context
- Build and promote new imaginary ideas about the research field
- Facilitate dialogue among the stakeholders

44 It is possible to see examples of *miniDOC* developed during the *Imagine Milan* project on the MovieDesignPolimi channel www.youtube.com/user/MovieDesignPolimi/featured.

Integrating the tool into the MSDS designing process

The *miniDOC* can be used as audiovisual output of the analysis phase.

- In **Strategic analysis**, the *miniDOC* may be used to:
  - Describe and visualise the key aspects (strengths and weaknesses) that emerged in the research phase. It may be useful to identify contexts, actors and clusters in a format that serves as a good starting point for a dialogue among decision-makers, as audiovisual material is easy to access and understand (see Figure 4.60)

Figure 4.60 **Concept table to describe key aspects of the context and frame extract from a miniDoc visualisation**

How to use the tool

The tool requires the use of editing and compositing software. It is thus based on narrative structures.

The *miniDOC* not only allows all stakeholders to be involved in the material collection (iconographic repertoires and video interviews), but it also forces designers to gather and organise the key elements into narrative and aesthetic clusters. Hence the context investigated becomes a source of inspiration for the development of the project.

Materials can be collected with different devices (video cameras, mobile phones, or cameras) that edited can easily convey the complexity of information. Designers can present different interactions by combining recorded materials, infographics and audio. It is also possible to transmit these outputs onto the net to manage online discussions (e.g. conference calls).

Table 4.7 **Phases in use of the miniDOC tool**

Phase	Activity
Concept	Listening Script Storyboard Aesthetic language
Pre-production	Historically and contemporary iconographic repertoires Video interviews
Production	Shooting Animation
Post-production	Editing Compositing

Results

The result is an audiovisual format based on a narrative structure able to show the current state of the art of the explored field.

Exploiting the potential of audiovisual storytelling, *miniDOC* allows stakeholders to produce reflections that become the source of inspiration for the subsequent design project.

Tool availability and resources required

The tool requires the use of editing and compositing software (e.g. Adobe Premiere, Final Cut or others for editing and After Effects or the equivalent for compositing).

Good communication and technical skills are required to create the storyline and the editing.

It is therefore recommended that a communication designer is employed who is able to translate the information gathered during the analysis with expertise that goes beyond visualisation.

The time required to set up a *miniDOC* varies according to the complexity of the project and is directly related to the output quality:

- A minimum technical time of 30 days for basic work (sufficient image quality, editing and storyline) that can be achieved with devices at one's disposal (e.g. mobile and free editing software)
- 40 days or more to achieve a good analysis output (good image quality, editing and storyline) for which technical and storytelling skills and structured goals are required

4.3.14 System concept Audiovisual[45]

Aims

The *System concept Audiovisual* is a visualisation tool conceived for idea generation; it is able to bring tangibility to ideas in order to shape the design project.

This tool, as well as *miniDOC*, enables production of a project output that visualises concepts, which become the starting point for a discussion among the actors.

In particular, the tool is a short video format (usually around three minutes) based on a three-act narrative structure:

- The first part shows the context
- The second part asks the typical design question for an envisioned future: 'what if…?'
- The last part visualises a possible solution

The aim is to show possible concepts and to stimulate imagination and conversation among different actors.

System concept Audiovisual has been developed to be a useful tool for the design process enabling the sharing of concepts among the various project participants.

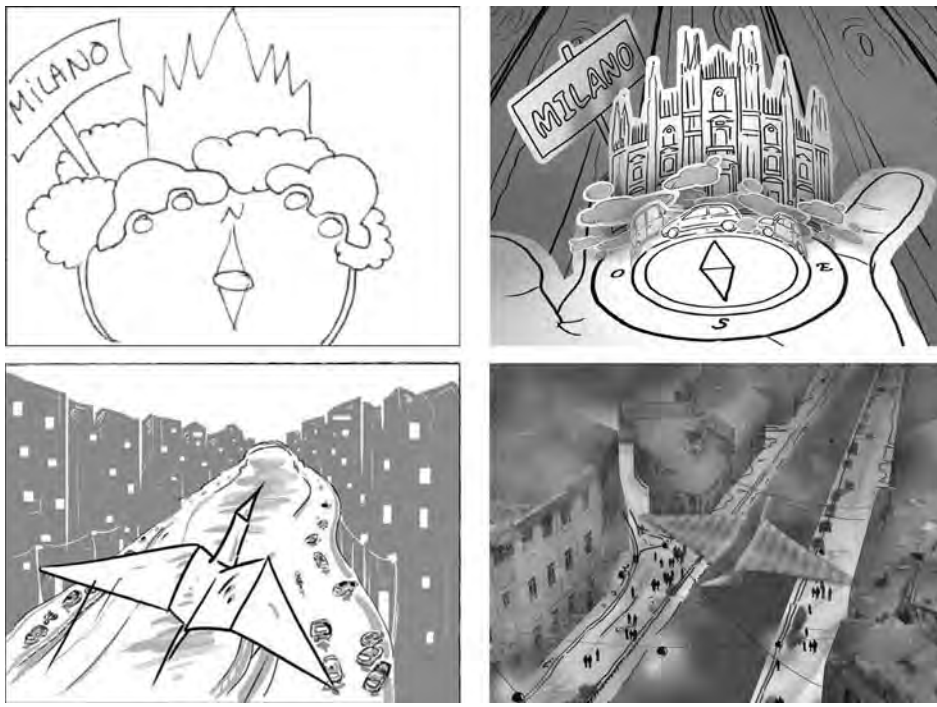
Integrating the tool into the MSDS designing process

The *System concept Audiovisual* becomes increasingly detailed throughout the designing process.

- When **System concept designing**, the *System concept Audiovisual* may be used to:
  - Visualise possible design concepts to encourage comparison among different points of view. This allows stakeholders to identify needs and to develop a shared path with the design team
- When **Communicating**, the *System concept Audiovisual* may be used to:
  - Visualise developed design concepts to communicate and disseminate results. It allows relation of different mental images that are involved in the construction of a shared concept (see Figure 4.61)

45 *System concept Audiovisual* is usually known as Audiovisual Scenario: for further theoretical information see Piredda 2008.

Figure 4.61 **Example of how the System concept Audiovisual communicates results**



How to use the tool

To support the most effective and creative dialogue, it is recommended that a communication designer works with the design team on these activities:

- Listening—organising the key functions (strengths and weaknesses) into narrative and aesthetic clusters
- Script and storyboard—definition of the storyline and storyboard
- Production of the audiovisual visualisation

In *System concept Audiovisual* the stakeholders have the main role and cooperate with the design team on the definition of the ideas themselves: they are able to enrich the images' meaning with their ideas, knowledge and experiences.

Table 4.8 **Phases in use of the System concept Audiovisual tool**

Phase	Activity
Concept	Listening Script Storyboard Aesthetic language
Pre-production	Material search (images, photos, drawing…)
Production	Shooting Animation
Post-production	Editing Compositing

Results

The result is an audiovisual output able to visualise ideas (using aesthetic languages appropriate to the objective) that are generated during the design process: hence communication design can provide an epistemological and aesthetic contribution to envisioning a possible future.

Tool availability and required resources

The tool requires good communication, storytelling and technical skills.

For the listening activity the involvement of all participants is suggested for the organisation of the key functions and the generation of ideas.

Good writing and graphic skills are required to create the storyline and the images for the storyboard, which could be directly drawn on paper or created using photo editing software.

For Pre-production, Production and Post-production activities good skills in editing and compositing are necessary.

The time required to create a *System concept Audiovisual* varies with the complexity of the visualisation. These are semi-finished products that overlap sketches and drawings with photographic backgrounds, in which the audiovisual format allows the multiplication of points of view in time and space. It will therefore require

- A minimum technical time of 5 days. This type of *System concept Audiovisual* requires good listening and storytelling skills, where technical skills are related to the aesthetic quality of the visualisation. A good technique can be the integration of heterogeneous materials that are collected with new devices: the *Mash-up*

- A minimum technical time of 15 days for a *System concept Audiovisual* able to visualise complex ideas and tales that require a sophisticated image culture and advanced technical skills (e.g. Rendering or Fiction). This type of *System concept Audiovisual* can be used in the final step of System concept designing and in the Communicating stage

4.3.15 Animatic

Aims

The *Animatic* is a visualisation tool able to support the co-design process.

It is an animated interaction storyboard that edits images with dialogues and sounds. This audiovisual tool allows the design team to visualise a detailed sequence, giving an idea of the action time. It could be created after and on the basis of a (static) interaction storyboard and could make the same narration more effective.

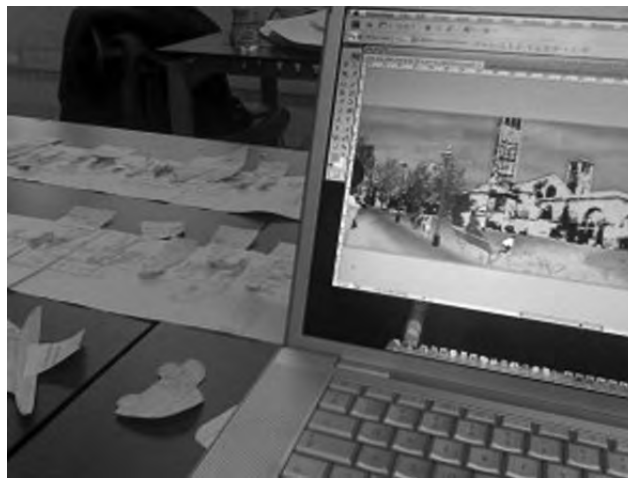
In essence the tool is an audiovisual representation able to:

- Visualise a detailed sequence
- Add information about actions' duration
- Promote a collective conversation among the actors involved

Integrating the tool into the MSDS designing process

- When **Exploring opportunities**, *Animatic* can be used to:
  - Visualise the different phases of a new idea to make it understandable and facilitate the learning process. It is a semi-finished product that can represent process and relations in a schematic way and can promote a collective conversation
- When **System concept designing**, the *Animatic* may be used to:
  - Describe a draft concept, visualising an action sequence with an indication of time and space. This simulation allows the design team to gather different points of view on the project (see Figure 4.62)

Figure 4.62 **Example of a work-in-progress Animatic, a simple video-collage with dialogues and sounds**



How to use the tool

Animatic can be used as an internal communication and co-design tool. It is a simple video-collage obtained from a linear editing of drawings and images coming from an interaction storyboard, with dialogues and sounds. For graphic elements it is advisable to use graphic image processing software. For drawing up a storyline able to render the gathered materials the use of slideshow software (e.g. PowerPoint or the equivalent in Open Office) or basic editing software is recommended.

Table 4.9 **Phases in use of the Animatic tool**

Phase	Activity
Concept	Script Storyboard
Production	Search material (images, photos, drawings…) Images processing
Post-production	Linear editing

Results

The result is an audiovisual output made up of heterogeneous materials collected with different devices. It is a step beyond an animated storyboard that can visualise ideas to promote dialogue among stakeholders. *Animatic* can evolve in greater and greater detail during the design process up to the complexity of the *System concept Audiovisual* tool.

Tool availability and required resources

The tool requires basic graphic, storytelling and technical skills.

The time required to create an *Animatic* varies with the complexity of the visualisation and the narrative quality. It will require approximately:

- A minimum technical time of 2 days for a video-collage derived from a linear editing of drawings and images coming from the storyboard with dialogues and sounds (e.g. slideshow or simple video). This tool requires basic graphic skills to create the images (sketches, drawings or photo background) and basic storytelling expertise. Technical skills are related to the aesthetic quality of the visualisation

Table 4.10 **Time requirement approximations when using the Animatic tool**

Phase	Activity	Time
Concept	Script Storyboard	6 hours to define a simple storyboard
Production	Search material (images, photos, drawing…) Record dialogues and sounds	4 hours to select images from storyboard and other materials 5 hours to record dialogues and sounds
Post-production	Linear editing	8 hours to edit the collected materials

The following chapters in Part 2 of this volume will present a range of perspectives on PSS research: the research frontiers in Product-Service System Design for Sustainability.

Bibliography

Andersen, M. (2006) 'System transition processes for realising sustainable consumption and production', *Proceedings of Perspectives on Radical Changes to Sustainable Consumption and Production (SCP),* Sustainable Consumption Research Exchange (SCORE!) Network (Copenhagen).

Appadurai, A. (1996) *Modernity at Large: Cultural Dimensions of Globalization* (Minneapolis: University of Minnesota Press).

Baden-Powell, B.H. (1957) *The Indian Village Community* (New Haven: HRAF Press).

Baines, T. S., H.W. Lightfoot, S. Evans, A. Neely, R. Greenough, J. Peppard, R. Roy, E. Shehab, A. Braganza, A. Tiwari, J.R. Alcock, J.P. Angus, M. Bastl, A. Cousens, P. Irving, M. Johnson, J. Kingston, H. Lockett, V. Martinez, P. Michele, D. Tranfield, I.M. Walton, H. Wilson (2007) *State-of-the-art in product-service systems* (Cranfield, UK: Innovative Manufacturing Research Centre, Cranfield University).

Bauman, Z. (2000) *Liquid Modernity* (Oxford: Polity Press Cambridge - Blackwell Publishers) (Italian translation 2002, *Modernità liquida*, Roma-Bari: Laterza).

Behrendt, S., C. Jasch, J. Kortman, G. Hrauda, R. Pfitzner, and D. Velte (2003) *Eco-Service Development: Reinventing Supply and Demand in the European Union* (Sheffield, UK: Greenleaf Publishing).

Bijma, A., M. Stuts and S. Silvester (2001) 'Developing Eco-efficient Product-Service Combinations', in *Proceedings of the 6th International Conference 'Sustainable Services and Systems. Transition towards Sustainability?'*, The Surrey Institute of Art and Design, University College, Amsterdam, Netherlands, October 2001: 239-245.

Bistagnino, L. (2009) *Design sistemico. Progettare la sostenibilità produttiva e ambientale* (Italy: Slow Food Publishing).

Brandstotter, M., Haberl, M., Knoth, R., Kopacek, B., and Kopacek, P. (2003) 'IT on demand – towards an environmental conscious service system for Vienna (AT)', *Third International Symposium on Environmentally Conscious Design and Inverse Manufacturing – EcoDesign'03* (IEEE Cat. No.03EX895).

Brezet, H. and C. van Hemel (1997) *Ecodesign: A promising approach to sustainable production and consumption* (UNEP, Parigi).

Brezet, J.C., A.S. Bijma, J. Ehrenfeld and S. Silvester (2001) 'The Design of Eco-Efficient Services: Method, Tools and Review of the Case Study Based 'Designing Eco-Efficient Services" (Delft, the Netherlands: Dutch Ministries of Environment VROM & Delft University of Technology).

Brown, R. (2010) *Gandhi's Spinning Wheel and the Making of India* (UK: Routledge).

Carniatto, V. and E. Chiara (2006) 'Design for a fair economy', in Proceedings of P&D conference, Curitiba, Brazil.

Carniatto, V., F.V. Carneiro and D.M.P. Fernandes (2006) *Design for sustainability: a model for design intervention in a Brazilian reality of local sustainable development*, in Proceedings, international design conference, Dubrovnik, Croatia.

Castells, M. (1996, second edition, 2000) *The Rise of the Network Society, The Information Age: Economy, Society and Culture Vol. I.* (Cambridge, MA; Oxford, UK: Blackwell).

Ceschin, F. (2006) *Mobilità sostenibile per i trasporti leggeri. Progettazione di un sistema di prodotto-servizio per un quadri ciclo leggero a energia solare e muscolare.* Master's degree thesis, Politecnico di Milano, Faculty of Design.

Ceschin, F. (2010) 'How to facilitate the implementation and diffusion of sustainable Product-Service Systems? Looking for synergies between strategic design and innovation sciences' in Ceschin, F., Vezzoli, C. and Zhang, J. *Sustainability in design: now! Challenges and opportunities for design research, education and practice in the XXI century. Proceedings of the Learning Network on Sustainability (LeNS) conference (vol. 1)*, Bangalore, India, 29 September – 1 October 2010 (Sheffield, UK: Greenleaf Publishing).

Ceschin, F., and C. Vezzoli (2007) 'Sustainable product-service systems development. Application and evaluation of the SDOS (Sustainability Design-orienting Scenario) methodology for the upstream waste reduction in the food and in the paper chains in the city of Brescia' in FHNW (School of Life Sciences - Institute for Ecopreneurship) 11th European Roundtable on Sustainable Consumption and Production (ERSCP 2007), Basel, Switzerland, 20-22 June 2007.

Ceschin, F., and C. Vezzoli (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* 10.2/3: 321–341.

Charter, M. and U. Tischner (2001) *Sustainable Solutions: Developing Products and Services for the Future* (Sheffield, UK: Greenleaf Publishing).

Chiapponi, M. (1989) *Ambiente: gestione e strategia. Un contributo alla teoria della progettazione ambientale* (Feltrinelli, Milan).

Cooper, T. and E. Sian (2000) *Products to Services* (Friends of the Earth, Centre for Sustainable Consumption, Sheffield Hallam University).

Cortesi, S., C. Vezzoli and C. Donghi (2010) 'Case study of the design of Eco-Efficient Product-Service-System for KONE Corporation, using the MSDS method and tools' in Ceschin, F., Vezzoli, C. and Zhang, J. (eds.) Sustainability in design: now! Challenges and opportunities for design research, education and practice in the XXI century. Proceedings of the Learning Network on Sustainability (LeNS) conference (vol. 2), Bangalore, India, 29 September - 1 October 2010 (Sheffield, UK: Greenleaf Publishing).

Crul, M. (2003) *Ecodesign in Central America* (Delft, the Netherlands: Delft University of Technology).

Crul, M. and J.C. Diehl (2006) *Design for sustainability: A practical approach for developing economies* (Paris: United Nations Environment Programme; TU Delft).

Crul, M. and J.C. Diehl (2008) 'Design for Sustainability (D4S): Manual and Tools for Developing Countries', in Proceedings, 7th Annual ASEE Global Colloquium on Engineering Education, Cape Town, South Africa, 19-23 October 2008.

Dahlberg, K. and A.M. Jansson (1998) 'Sustainable regional food supply: analysis of food consumption patterns, local production and external dependence from the perspective of wholesalers and retailers of food' in Dwyer, S., Ganslosser, U., and O'Conner, M. (eds.) *Life Science Dimensions – Ecological Economics and Sustainable Use* (Filander Verlag): 409-419.

Diehl, J.C. and J.C. Brezet (2003) 'Ecodesign methodology, tools and knowledge transfer', in Corte-Real, E., C.A.M. Duarte and F. Carvalho Rodrigues (eds.) *Senses and sensibility in technology: linking tradition to innovation through design* (Lisbon: Instituto de Artes Visuais Design e Marketing).

Eames, C. and R. Eames (1958) *The India Report* (Ahmedabad: NID).

Ehrenfeld, J.R. (2008) *Sustainability by Design: A Subversive Strategy for Transforming Our Consumer Culture* (Yale University Press).

EMUDE (2006) *Emerging User Demands for Sustainable Solutions final report*, 6th Framework Programme (priority 3-NMP), European Community.

EU (2003) *Directive 2005*/32/CE, establishing a framework for the setting of ecodesign requirements for energy-using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council, Official Journal of the European Union.

EU (2006) *Renewed Sustainable Development Strategy*, Council of the European Union. No. 10117/06, Brussels.

EU (2009) *2009 Review of the European Union Strategy for Sustainable Development,* Brussels.

FAO, WFP and IFAD (2012) *The State of Food Insecurity in the World 2012: Economic growth is necessary but not sufficient to accelerate reduction of hunger and malnutrition* (Rome: Food and Agriculture Organization of the United Nations).

Flavin, C., and Gardner G. (2006) *State of the World 2006: China and India Hold World in Balance* (Washington, DC: Worldwatch Institute).

Florida, R. (2002) *The Rise of the Creative Class and How It is Transforming Work, Leisure, Community and Everyday Life* (New York: Basic Books).

Fusakul, S.M. and P. Siridej (2010) 'DSEP: implementation of Sufficiency Economy Philosophy in design' in Ceschin, F., Vezzoli, C. and Zhang, J. (eds.) *Sustainability in design: now! Challenges and opportunities for design research, education and practice in the XXI century. Proceedings of the Learning Network on Sustainability (LeNS) conference (vol. 1)*. Bangalore, India, 29 September – 1 October 2010 (Sheffield, UK: Greenleaf Publishing).

Gadgil, M. (1985a) 'Social Restraints on Resource Utilization: The Indian Experience', in J.A. McNeely and D. Pitt (eds.) *Culture and Conservation: The Human Dimension in Environmental Planning* (Dublin: Croom Helm).

Gadgil, M. (1985b) 'Cultural Evolution of Ecological Prudence'. *Landscape Planning* 12: 285-99.

Geels, F. (2002) *Understanding the dynamics of technological transitions: a co-evolutionary and socio-technical analysis*, The Netherlands: Phd University Twente (Enschede).
Geels, F.W. (2004) 'From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory', *Research Policy* 33.6/7: 897-920.
Geyer-Allely, E. (2002) 'Sustainable consumption: an insurmountable challenge', in *Industry and Environment Review* (UNEP).
Gandhi, M. (1932) *From Yeravada Mandir: Ashram Observances* (V. G. Desai, Trans.) (Ahmedabad: Navjivan Publishing House).
Gandhi, M. (1960a) *Bread Labour (The Gospel of Work)* (Ahmedabad: Navjivan Publishing House).
Gandhi, M. (1960b) *Trusteeship* (Compilation by Ranindra Kalekar) (Ahmedabad: Navjivan Publishing House).
Gandhi, M. (2009) *Essence of Hinduism* (English Paperback edition) (Ahmedabad: Navjivan Publishing House).
Giudice, F., G. La Rosa and A. Risitano (2006) *Product Design for the Environment. A Life Cycle Approach* (USA: CRC Press, Taylor and Francis Group).
Goedkoop, M., C. van Halen, H. te Riele and P. Rommes (1999) *Product Service Systems, Ecological and Economic Basics*, report 1999/36 (the Hague: VROM).
Granovetter, M. (1985) 'Economic Action and Social Structure: The Problem of Embeddedness', *American Journal of Sociology* 91(3): 481-510.
GRI (2006) *G3 Sustainability Reporting Guidelines,* Global Reporting Initiative
Guadagnucci, L. and F. Gavelli (2004) *La crisi di crescita. Le prospettive del commercio equo e solidale* (Milan: Feltrinelli).
Guanzhong, L. (2006) *Science of human affairs* (Changsha, China: Central South University Press).
Guanzhong, L. (2009) 'Urgent need to re-understand the "origin" and "primacy": reflection from industry chain' (Beijing, China: Yishubaijia).
Hart, S.L. and M.B. Milstein (1999) 'Global sustainability and the creative destruction of industries', *Sloan Management Review* 41.1: 23-33.
Heiskanen, E. (2002) 'The institutional logic of life cycle thinking', *Journal of Cleaner Production* 10(5).
Hemel, C.G. van (2001) 'Design for environment in practice: three Dutch industrial approaches compared', in 4th NTVA industrial ecology seminar and workshop: industrial ecology - methodology and practical challenges in industry.
Henderson, R.M. and K.B. Clark (1990) 'Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms', *Administrative Science Quarterly* 35.1: 9-30.
Hockerts, K. (1998) 'Eco-Efficient Service Innovation: Increasing Business-Ecological Efficiency of Products and Services', in M. Charter (ed.) *Greener Marketing: A Global Perspective on Greener Marketing Practice* (Sheffield, UK: Greenleaf Publishing): 95-108.
ISO 14062 (2002) *Environmental Management – Integrating Environmental Aspects into Product Design and Development*, ISO/TR 14062:2002(E) (ISO, Geneva).
James, P., and P. Hopkinson (2002) *Service innovation for sustainability. A new option for UK environmental policy?* (Bradford: Bradford University).
Jégou, F., Manzini, E., and Meroni, A. (2004) 'Design plan. A design toolbox to facilitate solution oriented partnerships' in Manzini, E., Collina, L., and Evans, S. (eds.) *Solution oriented partnership* (Cranfield: Cranfield University).
Jenkins, P. (2000) *Mystics and Messiahs: Cults and New Religions in American History* (Oxford: Oxford University Press).
Johansson, A., Kisch, P. and M. Mirata (2005) 'Distributed economies: A new engine for innovation', *Journal of Cleaner Production* 13: 971-979.

Joore P. (2006) 'Guide Me: Translating a broad societal need into a concrete product service solution', Proceedings, Perspectives on Radical Changes to Sustainable Consumption and Production (SCP), Sustainable Consumption Research Exchange (SCORE!) Network, Copenhagen.

Kandachar, P. (2010) 'Designing for global sustainable solutions: challenges and opportunities' in Ceschin, F., Vezzoli, C. and Zhang, J. (eds.) *Sustainability in design: now! Challenges and opportunities for design research, education and practice in the XXI century. Proceedings of the Learning Network on Sustainability (LeNS) conference (vol. 1)*. Bangalore, India, 29 September - 1 October 2010. (Sheffield, UK: Greenleaf Publishing).

Karlsson, R. and C. Luttrop (2006) 'EcoDesign: what is happening? An overview of the subject area of Eco Design', *Journal of Cleaner Production* 14 (15-16).

Keoleian, G.A. and D. Menerey (1993) *Life Cycle Design Guidance Manual: Environmental requirements and the product system* (USA: EPA).

Kohtala, C. and Vezzoli, C. (eds.) (2010) *A World of Sustainable Ideas*, LeNS Award Catalogue [Online], Available at www.lens.polimi.it.

Leach, E.R. (1960) 'Introduction: What Should We Mean by Caste?' In E. R. Leach (ed.) *Aspects of Caste in South India, Ceylon and North West Pakistan* (Cambridge: Cambridge University Press).

Leong, B. (2006) 'Is a Radical Systemic Shift toward Sustainability possible in China?', in Proceedings, Perspectives on Radical Changes to Sustainable Consumption and Production (SCP), Sustainable Consumption Research Exchange (SCORE!) Network, Copenhagen.

Lindhqvist, T. (2000) *Extended Producer Responsibility in Cleaner Production*, Doctoral dissertation, IIIEE Lund University, Lund.

Maase, S. and K. Dorst (2006) 'Co-creation: A way to reach sustainable social innovation?', in Proceedings, Perspectives on Radical Changes to Sustainable Consumption and Production (SCP), Sustainable Consumption Research Exchange (SCORE!) Network, Copenhagen.

Maldonado, T. (1970) *La speranza progettuale*. Ambiente e società (Turin: Einaudi).

Mance, E. (2001) A revolução das redes. A colaboracão solidária como una alternativa pós-capitalista à globalização atual (Petrópolis: II ed., Editora Vozes).

Manzini, E. and F. Jégou (2003) *Sustainable Everyday: Scenarios of Urban* Life (Milan: Edizioni Ambiente).

Manzini, E. and C. Vezzoli (1998) *Lo sviluppo di prodotti sostenibili* (Rimini: Maggioli editore).

Manzini, E. and C. Vezzoli (2001) 'Strategic design for sustainability', in TSPD proceedings, Amsterdam.

Manzini, E., C. Vezzoli and G. Clark (2001) 'Product-Service Systems: Using an Existing Concept as a New Approach to Sustainability', *Journal of Design Research* 1.

Manzini, E., L. Collina and S. Evans (eds.) (2004) *Solution oriented partnership* (Cranfield: Cranfield University).

Marchand, A. and S. Walker (2006) 'Designing alternatives', Proceedings, Perspectives on Radical Changes to Sustainable Consumption and Production (SCP), Sustainable Consumption Research Exchange (SCORE!) Network, Copenhagen.

Margolin, V. (2002) *The Politics of the Artificial* (Chicago: University of Chicago Press).

Marks, N., S. Abdallah, A. Simms and S. Thompson (2006) *The (Un)Happy Planet: An Index of Human Well-Being and Environmental Impact* (London, UK: New Economics Foundation and Friends of the Earth).

Meadows, D., D. Meadows and J. Randers (2006) *Limits to Growth: The 30-year update* (Chelsea Green, White River Junction, VT).

Meier, H., R. Roy, and G. Seliger (2010) *Industrial Product-Service Systems - IPS²*, Manufacturing Technology Journal.

Meroni, A. (ed.) (2007) *Creative Communities: People Inventing Sustainable Ways of Living* (Milan: Edizioni Polidesign).

Mont, O. (2002) *Functional thinking: The role of functional sales and product service systems for a functional based society*, research report for the Swedish EPA (Lund, Sweden: IIIEE Lund University).
Mont, O. (2004) *Product-service systems: Panacea or myth?* PhD Dissertation. IIIEE, University of Lund, Sweden.
Mont, O., and T. Lindhqvist (2003) 'The Role of Public Policy in Advancement of Product Service Systems', *Journal of Cleaner Production* 11.8: 905-914.
Mont, O. and Plepys, A. (2004) 'From ownership to service-based lifestyle: the case of joint use of power tools', The Society for Non-Traditional Technology (Japan: Tokyo).
Morelli, N. (2006a) 'Developing new product service systems (PSS): methodologies and operational tools', *Journal of Cleaner Production*, 14.
Morelli, N. (2006b) 'New representation techniques for designing in a systemic perspective' paper presented at the 'Engineering and product design education' conference, Salzburg University of Applied Sciences, Salzburg, Austria, 7-8 September 2006.
Nes, van N. and J. Cramer (2006) 'Product life time optimization: a challenging strategy towards more sustainable consumption patterns', *Journal of Cleaner Production* 14 (15-16).
Papanek, V. (1971) *Design for the Real World* (published in Italy by Arnaldo Mondatori Editore, Milan).
Penin, L. (2006) *Strategic design for social sustainability in emerging contexts*, PhD thesis, Politecnico di Milano, Milan.
Piredda (2008) 'Design e comunicazione delle pratiche sociali tra cinema, televisione e Web', *Convergências* 2. Retrieved from www.convergencias.esart.ipcb.pt/artigo/23.
Porter, M.E. and M.R. Kramer (2006) 'Strategy and Society: The Link Between Competitive Advantage and Corporate Social Responsibility', *Harvard Business Review*, December.
Prasad, S. (2010) *Farm Innovators* (Delhi: ICAR).
Rana, N. (2010, October 28 Thursday) 'Trusteeship, Gandhi and Business in the 21st Century'. Retrieved from 'Living Principle' blog <www.livingprinciples.org/trusteeship-gandhi-and-business-in-the-21st-century>.
Razeto, L. (2002) *Las empresas alternativas* (Montevideo, Uruguay: Nordam).
Rifkin, J. (2000) *The Age of Access: How to shift from ownership to access in transforming capitalism* (London: Penguin Books).
Rifkin, J. (2002) *The Hydrogen Economy: The creation of the worldwide energy web and the redistribution of power on earth* (Los Angeles: Jeremy P. Tarcher).
Rifkin, J. (2010) *The Empathic Civilization: The Race to Global Consciousness in a World in Crisis* (New York: Jeremy P. Tarcher).
Rifkin, J. (2011) *The Third Industrial Revolution* (New York: Jeremy P. Tarcher).
Rip, A., and R. Kemp (1998) 'Technological Change', in S. Rayner and E.L. Malone (eds.) *Human Choice and Climate Change,* Vol. 2 (Columbus: Batelle Press): 327-399.
Rocchi S. (2005) *Enhancing Sustainable Innovation by Design: An Approach to the Co-creation of Economic, Social and Environmental Value*, Doctoral Dissertation (Erasmus University, Rotterdam).
Rocha C., Frazao R., Zackrisson M., Christianseb K. (2006) 'The use of communication tools and policy instruments to facilitate changes towards sustainability', Proceedings, Perspectives on Radical Changes to Sustainable Consumption and Production (SCP), Sustainable Consumption Research Exchange (SCORE!) Network, Copenhagen.
Ryan, C. (2003) 'Learning from a Decade (or So) of Eco-Design Experience' (part one), *Journal of Industrial Ecology* 7 (2).
Ryan, C. (2004) *Digital Eco-Sense: Sustainability and ICT – a New Terrain for Innovation,* (Melbourne: Lab 3000).
Sachs, W. and T. Santarius (2007) *Per Un futuro Equo. Conflitti sulle risorse e giustizia globale. Un rapport del Wuppertal Institut* (Milan: Feltrinelli).

Sachs, W., H. Acselrad, F. Akhter, A. Amon, T.B.G. Egziabher, H. French, P. Haavisto, P. Hawken, H. Henderson, A. Khosla, S. Larrain, R. Loske, A. Roddick, V. Taylor, C. von Weizsäcker, S. Zabelin (2002) *The Jo'burg-Memo: Fairness in a Fragile World, Memorandum for the World Summit on Sustainable Development* (Berlin: Heinrich Böll Foundation).

SAI, *Social Accountability 8000*, www.sa8000.info/sa8000doc/2001StdEnglish.pdf

Sangiorgi, D. (2005) *Interaction story board*, in van Halen, C., Vezzoli C., Wimmer R. (eds.), *Methodology for Product Service System Innovation: How to develop clean, clever and competitive strategies in companies* (Assen: Van Gorcum).

Santos dos, A. (2008) 'Strategies of Change Towards Sustainability: The South American Experience', in Cipolla, C. and Peruccio, P.P. (eds.) *Changing the Change: Design, visions, proposals and tools* Conference Proceedings, Turin, Italy, 10-12 July 2008 (Torino: Umberto Allemandi & C.).

Santos dos, A., A. Krämer and C. Vezzoli (2009) 'Design Brings Innovation to the Base of the Pyramid', *Design Management Institute Review* 20(2).

Scholl, G. (2006) 'Product Service Systems', in Proceedings, Perspectives on Radical Changes to Sustainable Consumption and Production (SCP), Sustainable Consumption Research Exchange (SCORE!) Network, Copenhagen.

Sen, A. (1999) *Development as freedom* (Oxford: Oxford University Press).

Sheri, L. (2010) *Look Around: Chats with Chinese and Foreign Philosophizers about Green Prescriptions* (Beijing, China: Sunchime Film Library Audiovisual Press).

Soumitri, V. and C. Vezzoli (2002) 'Product Service System Design: Sustainable opportunities for all. A design research working hypothesis. Clothing care System for Kumaon Hostel at IIT Delhi', in Proceedings, Ecodesign international conference, New Delhi.

Stahel, R.W. (1997) 'The Functional Economy: Cultural Change and Organizational Change', in Richards, D.J. *The Industrial Green Game* (Washington: National Academic Press).

Stahel, W. (2001) 'Sustainability and Services', in Charter, M. and U. Tischner (eds.) *Sustainable Solutions – Developing products and services for the future* (Sheffield, UK: Greenleaf Publishing).

Stiglitz J. (2002) *Globalization and its discontents* (USA: W.W. Norton & Company).

Stoughton, M., Shapiro, K., Feng, L., and E. Reiskin (1998) *The business case for EPR: a feasibility study for developing a decision-support tool* (Boston, USA: Tellus Institute).

Sun, J., B. Han, S. Ekwaro-Osire, and H.-C. Zhang (2003) 'Design for Environment: Methodologies, tools, and implementation', *Journal of Integrated Design and Process Science* 7(1).

Tamborrini P. (2005) *L'impegno dell'ecodesign per una società sostenibile*, conference proceedings Formazione sviluppo sostenibile e Design, Politecnico di Milano.

Tischner, U. (2010) 'Design for Sustainability: where are we and where do we need to go?' in Ceschin, F., Vezzoli, C. and Zhang, J. (eds.) *Sustainability in design: now! Challenges and opportunities for design research, education and practice in the XXI century. Proceedings of the Learning Network on Sustainability (LeNS) conference (vol. 1)*. Bangalore, India, 29 September - 1 October 2010 (Sheffield, UK: Greenleaf Publishing).

Tischner, U. and M. Verkuijl (2006) 'Design for (social) sustainability and radical change', in Proceedings, Perspectives on Radical Changes to Sustainable Consumption and Production (SCP), Sustainable Consumption Research Exchange (SCORE!) Network, Copenhagen.

Tischner, U. and C. Vezzoli (2009) 'Product-Service Systems: Tools and Cases', in M. Crul and J.C. Diehl (eds.) *Design for Sustainability (D4S): A Step-By-Step Approach* (United Nations Environment Programme UNEP).

Tischner, U., E. Schmincke and F. Rubik (2000) *Was ist EcoDesign* (Basel: Birkhauser Verlag).

Tischner, U., Ryan C., Vezzoli, C. (2009) *Product- Service Systems*. In *Design for Sustainability a global guide. Modules.* Crul M., Diehl J. C. (eds.), United Nations Environment Program (UNEP).

Tukker, A. and P. Eder (2000) Eco-design: European state of the art, ECSC-EEC-EAEC, Brussels.

Tukker, A. and U. Tischner (eds.) (2006) *New Business for Old Europe: Product Services, Sustainability and Competitiveness* (Sheffield, UK: Greenleaf Publishing).
Tukker, A., E. Stø and C. Vezzoli (eds.) (2008a) *Journal of Cleaner Production, Special issue* 16 (11).
Tukker, A., M. Charter, E. Stø, M.M. Andersen and C. Vezzoli (eds.) (2008b) *System Innovation for Sustainability 1. Perspectives on Radical Changes to Sustainable Consumption and Production* (Sheffield, UK: Greenleaf Publishing).
UN (1992) *Report of the United Nations conference on environment and development, Rio de Janeiro, 3-14 June 1992, Annex I, Rio declaration on environment and development* (Rio de Janeiro: UN General Assembly).
UN (2000) *55/2. United Nations Millennium Declaration*, at www.un.org/millennium/declaration/ares552e.htm.
UN (2002) *World summit on sustainable development: Draft political declaration*, submitted by the president of the summit, Johannesburg.
UNEP (2000) *Achieving Sustainable Consumption Patterns: The Role of the Industry* (Paris: United Nations Environment Programme IE/IAC).
UNEP (2002) *Product-Service Systems and Sustainability: Opportunities for Sustainable Solutions* (Paris: United Nations Environment Programme, Division of Technology Industry and Economics, Production and Consumption Branch).
UNEP (2009) *Design for sustainability. A step-by-step approach* (Paris, France: UNEP).
UNFPA (2006) *State Of World Population 2006*, United Nations Population Fund, Thoraya Ahmed Obaid, Executive Director.
van Halen, C., Vezzoli, C., and Wimmer, R. (eds.) (2005) *Methodology for Product Service System. How to develop clean, clever and competitive strategies in companies* (Assen, Netherlands: Van Gorcum).
Vergragt, P.J. (2002) *Strategies towards the Sustainable Household. Final report* (Delft: TBM, Delft University of Technology).
Vezzoli, C. (2003a) *Systemic design for sustainability*, in Proceedings, Cumulus working paper, UIAH, Helsinki.
Vezzoli, C. (2003b) 'A new generation of designer: perspective for education and training in the field of sustainable design. Experiences and projects at the Politecnico di Milano University', *Journal of Cleaner Production* 11: 1-9.
Vezzoli C. (2010) *System design for sustainability: Theory, methods and tools for a sustainable 'satisfaction-system' design*, 2nd edn (Milan, IT: Maggioli editore).
Vezzoli, C. (2011) 'System Design for Sustainability: The new research frontiers', In Z. Haoming, P. Korvenmaa and L. Xin (eds.) *Tao of Sustainability: Strategies in a globalisation context*, Proceedings, Academy of Arts and Design, Tsinghua University, Beijing, 27-29 October, 2011.
Vezzoli, C. and F. Ceschin (2009) 'Sustainable Scenarios for Upstream Waste Reduction in the Food Chain', in Hülsen and Ohnesorge *Food Science Research and Technology* (New York: Nova Publishers).
Vezzoli, C. and E. Manzini (2006) 'Design for sustainable consumption', in Proceedings, Perspectives on Radical Changes to Sustainable Consumption and Production (SCP), Sustainable Consumption Research Exchange (SCORE!) Network, Copenhagen.
Vezzoli, C. and E. Manzini (2008a) *Design for Environmental Sustainability* (London: Springer).
Vezzoli C. and E. Manzini (2008b) 'Review: design for sustainable consumption and production systems', in Tukker, A., Charter, M., Stø, E., Andersen, M.M. and C. Vezzoli (ed.) *System Innovation for Sustainability 1. Perspectives on Radical Changes to Sustainable Consumption and Production* (Sheffield, UK: Greenleaf Publishing).

Vezzoli, C. and D. Sciama (2006) 'Life Cycle Design: from general methods to product type specific guidelines and checklists: a method adopted to develop a set of guidelines/checklist handbook for the eco-efficient design of NECTA vending machines' *Journal of Cleaner Production* 14 (15-16).

Vezzoli C., E. Manzini and G. Clark (2001) 'Product-Service Systems: Using an Existing Concept as a New Approach to Sustainability', *Journal of Design Research* 1.

Vezzoli, C., L. Orbetegli and F. Ceschin (2006) 'Meno rifiuti altri modi di fare. Scenari (SDOS) di riduzione a monte dei rifiuti' Research report for the project 'Less waste: other ways of doing!', Politecnico di Milano.

Vezzoli C., F. Ceschin and R. Kemp (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.) *Proceedings, Changing the Change: Design, visions, proposals and tools* (Turin: Umberto Allemandi and C.).

Vezzoli, C., F. Ceschin and S. Cortesi (2009a) *Metodi e strumenti per il Life Cycle Design. Come progettare prodotti a basso impatto ambientale* (Rimini: Maggioli Editore).

Vezzoli, C., F. Ceschin and M. M'Rithaa (2009b) 'LeNS Africa: An African Learning Network on Sustainability for the development and diffusion of teaching materials and tools on Design for Sustainability in an open-source and copyleft ethos', 4th International Conference on Life Cycle Management, Cape Town, South Africa.

von Hippel, E. (2005) *Democratizing Innovation* (Cambridge, MA: MIT Press).

WBCSD, *Doing business with the poor. A field guide*, World Business Council for Sustainable Development www.wbcsd.org/web/development.htm.

WBCSD (World Business Council for Sustainable Development) (1996) *Eco-efficient Leadership for Improved Economic and Environmental Performance* (Geneva: WBCSD).

Weidema, B.P. (2005) 'The integration of economic and social aspects in Life Cycle Impact Assessment', paper 2.-0 LCA consultants, Copenhagen, Denmark.

White, A.L., M. Stoughton and L. Feng (1999) *Servicizing: The Quiet Transition to Extended Product Responsibility* (Boston, USA: Tellus Institute).

Wong, M. (2004) Implementation of innovative product service-systems in the consumer goods industry. PhD Thesis, Cambridge University.

Xin, L. (2010) 'Current Situation and Practice of Design for Sustainability in China', in F. Ceschin, C. Vezzoli and J. Zhang (eds.) *Sustainability in design: now! Challenges and opportunities for design research, education and practice in the XXI century. Proceedings of the Learning Network on Sustainability (LeNS) conference*. Bangalore, India, 29 September - 1 October 2010 (Sheffield, UK: Greenleaf Publishing): 540-549.

Xin, L. and L. Jikun (2011) 'Possible Opportunity: the concept and practice of product service system design', *Proceedings of the Dao of Sustainability Conference*, Beijing, China (Wuhan, China: Huazhong University of Science & Technology Press Co.): 27-30.

Zaring, O. (2001) *Creating Eco-Efficient Producer Services* (Goteborg: Goteborg Research Institute).

Zupi, M. (ed.) (2004) *La globalizzazione vista dal sud del mondo* (Rome: Laterza).

Appendix I **Design criteria and guidelines for system eco-efficiency**

In this appendix for each of the six environmental criteria identified in the previous chapters an organic set of guidelines are highlighted, intended to steer idea generation towards eco-efficient system solutions (e.g. the idea-generating tables from the Sustainability Design-Orienting toolkit software). These guidelines are thus aimed at supporting the idea-generating process where the objective is not to develop incremental improvements at product level but rather to propose possible innovations at system level, characterised by radical improvements from an environmental, socio-ethical and economic point of view. In this sense when defining the guidelines particular attention is paid to producing system level ideas, i.e. ideas regarding: 1) the products and services that constitute the offer; and 2) the configuration of actors able to produce/deliver that offer.

System life optimisation

- Complement product or infrastructure with services for their maintenance, reparability, substitution
- Complement product or infrastructure with services for their technological upgradeability
- Complement existing product or infrastructure with services that increase/enable their aesthetical or cultural upgradeability
- Complement product or infrastructure with services that increase their reconfigurability (adaptation in new location)
- Offer shared use services for products or infrastructures
- Offer service delivery platform for product sharing/re-use/second-hand selling

Transportation/distribution reduction

- Use digital infrastructures (i.e. internet) for transferring/accessing information
- Create alternative partnerships that enable long distance activities (use, maintenance, repair)
- Create partnerships optimising the use of local resources (info/data transfer)

- Create alternative partnerships that allow on-site production (info/data transfer)
- Merge the product/infrastructure offer, with services for their on-site assembly
- Create partnerships to reduce/avoid transportation and packaging of products or semi-finished products
- Merge the product/semi-finished product with the service of its transportation to optimise distribution
- Enable clients to re-use packing and reduce transportation
- Offer service that allows remote controlling for maintenance/repair of products

Resource reduction

- Complement energy/materials/semi-finished products, with support services for their optimal use
- Offer access to products or infrastructures (enabling platform) through payment based on the unit of satisfaction
- Offer access to products or infrastructures (enabling platform) through payment based on the annual fixed fee per given period of time
- Offer full-service (final result) to client/final user, through payment based on the unit of satisfaction
- Provide resource-saving technologies and practices to upgrade existing equipment, where the investment is financed via realised resources savings
- Offer collective use of products and infrastructures
- Outsource activities when higher specialisation and technological efficiency of products/infrastructures are available
- Create partnerships to use/integrate existing infrastructures/products
- Outsource activities when higher scale economies are feasible
- Add to product/infrastructure the design of their adaptation in the context of use aiming at resources optimisation
- Complement product/infrastructure, with design services for their adaptation to use in variations of resource requirements
- Offer products/semi-finished products on availability
- Offer products/semi-finished products on pre-determined demand

Waste minimisation/valorisation

- Complement product/infrastructure, with take back services aimed at re-using or re-manufacturing
- Complement product/infrastructure offer, with take back services aimed at recycling
- Complement product/infrastructure offer, with take back services aimed at energy recovery
- Add to product withdraw services aiming at composting
- Create localised alliances/partnership aiming at symbiotic/cascade approach for secondary resource use

Conservation/biocompatibility

- Create partnerships aiming at decentralised and renewable energy resources
- Create partnerships that increase the utilisation of local renewable and bio-degradable materials and produces
- Increase the utilisation of passive energy resources for infrastructure and products functioning
- Create partnerships that increase the utilisation of local recycled materials

Toxicity reduction

- Create partnerships with other producers to re-use or recycle toxic or harmful substances
- Complement the product, infrastructure, or semi-finished products with services that minimise/treat toxic or harmful emissions they cause in use
- Include end-of-life treatments when selling toxic or harmful substances
- Offer toxic management services to client/final user, through payment based on the unit of satisfaction

Appendix II **Design criteria and guidelines for social equity and cohesion**

As in Appendix 1, for each of the six socio-ethical criteria identified in the previous chapters an organic set of guidelines is highlighted, intended to steer idea generation towards social, equitable and cohesive system solutions (e.g. the idea-generating tables from the Sustainability Design-Orienting toolkit software).

Improve employment/working conditions

- Promote and enhance the protection of working conditions
  - Avoid/eliminate forced and under age work
  - Avoid/eliminate all forms of discrimination in the workplace
  - Provide freedom of association and right to collective negotiation
  - Define and adopt tools and standards of social and ethical responsibility certification of the companies
- Promote and enhance health and safety in working conditions
  - Improve the health and safety of workers
  - Define and adopt tools and standards of social and ethical responsibility certification of the companies
- Promote and enhance adequate working hours and fair wages
  - Guarantee that wages are fair and adequate to the amount of working hours (in the whole value chain)
  - Guarantee an adequate number of working hours
- Promote and enhance satisfaction, motivation and participation of the employees
  - Offer a work place adequate to employees' capacities
  - Guarantee a continuous formation and training period for workers
  - Avoid alienating jobs in favour of creative ones
  - Involve workers/employers in decision processes
  - Create a working climate that takes into consideration innovations suggested by the workers
  - Collaborate with colleagues to offer good working conditions in the whole value chain

Improve equity and justice in relation to stakeholders

- Promote and enhance fair and just partnerships
  - Support and involve partners in developing or emerging contexts
  - Support and involve partners active in social activities
  - Involve organisations engaged in the diffusion of social equity standards
  - Promote and facilitate the knowledge exchange inside partners' relationships
  - Extend to partners the definition and/or the adoption of standards and tools for social and ethical responsibility certification
  - Offer to stakeholders an adequate information flow
  - Increase stakeholders' productive capacity
- Promote and enhance equal and just relations with suppliers, subcontractors and sub-suppliers
  - Join the system of fair trade activities/development of aid activities
  - Promote cooperation projects in emerging and developing countries
  - Consider stakeholders' expectations and potentialities and give answer to suppliers/subcontractors needs and interests
  - Involve suppliers, subcontractors and sub-suppliers in design (and decision) processes
  - Promote/require that other companies which take part in the value chain safeguard the working conditions
  - Promote/require that other companies which take part in the value chain safeguard health and safety
  - Promote/require the adoption of social certification systems by suppliers, subcontractors and sub-suppliers
  - Define and/or adopt standards and tools for companies' social and ethical certification
- Promote and enhance equal and just relations with clients and/or end-users
  - Offer products and services which guarantee to the clients/final users' health and safety
  - Promote systems to improve health and safety conditions and reduce discrimination and marginalisation

  - Enhance the health and safety in working conditions of the products and services offered
  - Define and/or adopt standards and tools for the certification of social and ethical responsibility in relation to final users
- Promote and enhance equal and just relations affecting the community where the offer takes place
  - Verify that the offer does not have any rebound effects
  - Promote and enhance the quality and accessibility of common goods
- Promote and enhance equity and justice with local institutions/agencies
  - Support democratic structures through the system to be offered (e.g. in developing countries)

Enable a responsible/sustainable consumption

- Make transparent and enhance the social sustainability of all the stakeholders
  - Adopt standards in order to increase the transparency of supply, underlining its social sustainability
- Provide the information and/or learning experiences to educate the client/end-user on responsible/sustainable behaviour
- Develop offers that enable responsible/sustainable participation of the client/end-user
- Involve the client/end-user in the production/implementation/customisation of his/her own product-service systems towards responsible/sustainable behaviour
- Involve the client/end-user in the design/decision process, of his/her own product-service systems towards responsible/sustainable behaviour

Favour/integrate the weaker and marginalised

- Involve and improve the conditions for weaker social strata
- Involve and improve the conditions of marginalised persons
  - Involve and improve marginalised (e.g. unemployed) persons offering them qualifying jobs which enhance their competences
- Involve and facilitate introducing foreigners into the social context/space

- Develop systems to extend the access to goods and services to all social strata
  - Develop products or services for free or at a cost accessible even for people of low-income
  - Diversify the offer allowing higher or lower costs, to increase the access capacities
- Develop systems of shared usage and/or exchange of goods and services to increase their accessibility
  - Develop systems with shared economic property
  - Develop systems which promote labour services with equitable access/exchange
  - Develop systems (e.g. cooperatives) which involve product sharing and cost reductions
- Develop systems which allow easier access to credit (for companies)

Improve social cohesion

- Promote systems enabling neighbourhood social integration
  - Promote neighbourhood systems of sharing common goods and maintenance
  - Promote systems enabling inhabitants in common goods co-design
  - Promote co-housing systems
  - Promote co-working systems
- Promote systems enabling social integration between generations
- Promote systems enabling gender integration
- Promote systems enabling social integration between different cultures

Empower/enhance local resources

- Respect/enhance peculiar local cultural characteristics
  - Respect and encourage cultural identities and diversities
  - Encourage different tastes and aesthetics

- Develop a system to encourage and foster local economies
  - Reinforce the role of the local economy creating services in the same place where they will be used
  - Favour any development that enhances the local capacities for collaborated production of goods that contribute to the common goods and external economies
- Regenerate/enhance unused and disposed artefacts
  - Renew/regenerate urban artefacts that have fallen into disuse (e.g. involving weak persons)
  - Renew/regenerate industrial, domestic and urban dismissed products and materials
- Adapt/promote systems using regenerated natural, local resources
- Promote local-based and network-structured enterprises/initiatives
  - Promote/rely on distributed renewable energy generation network
  - Promote/rely on people collaborating (open and peer-to-peer) networks
  - Promote/rely on artefact collaboration (open and peer-to-peer) networks.