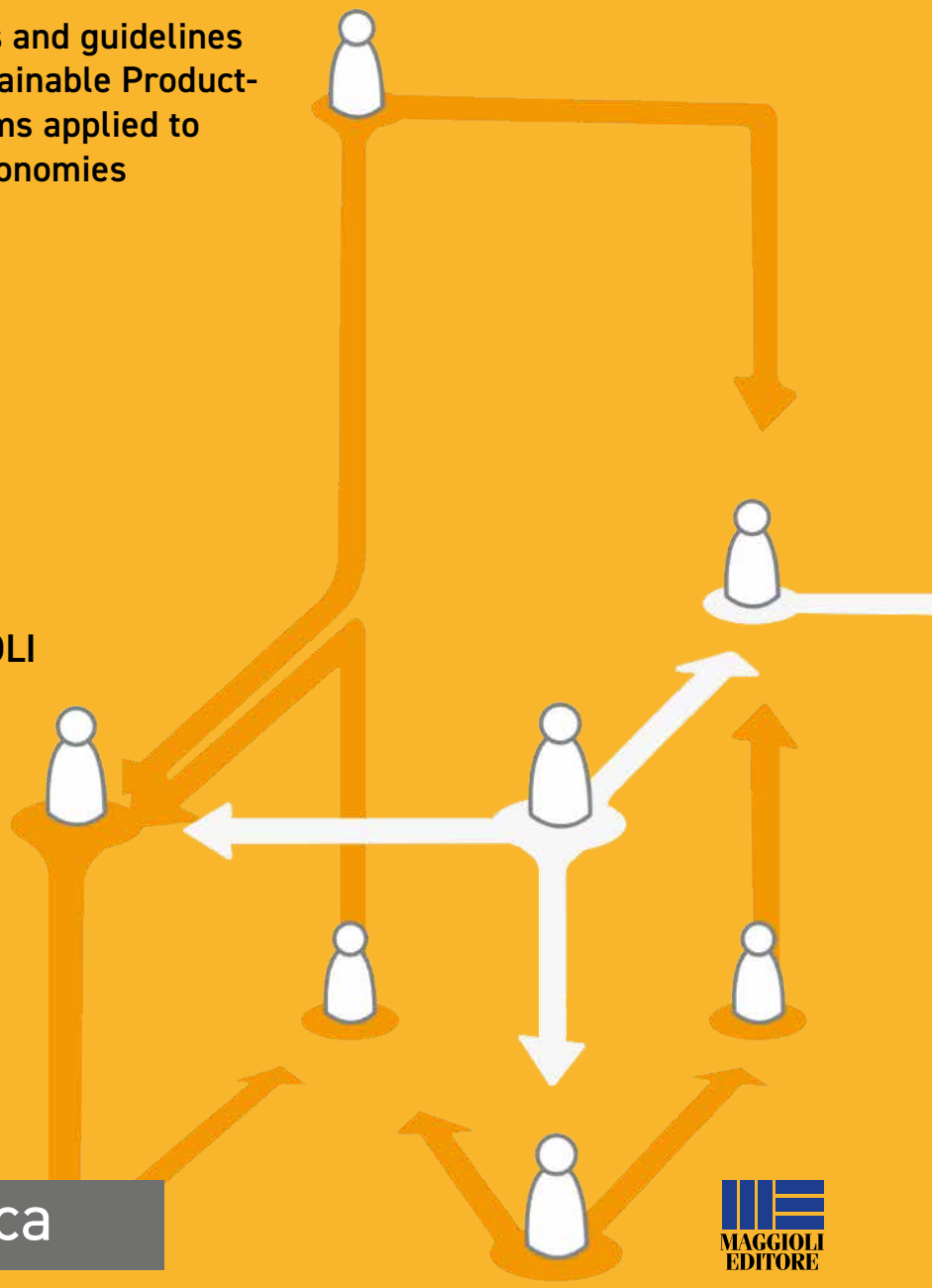
SYSTEM DESIGN FOR SUSTAINABILITY IN PRACTICE

Methods, tools and guidelines to design Sustainable Product-Service Systems applied to Distributed Economies



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Summary

Transitioning towards sustainability requires radical changes in the way we produce, consume and live. System innovations are therefore necessary for achieving sustainable transitions. The aim of this book is to describe and support the practice of System Design for Sustainability (SDS) focused on two promising models: Sustainable Product-Service Systems (S.PSS) and Distributed Economies (DE).
Sustainable Product-Service Systems offer win-win opportunities by combining the three pillars of economic, environmental, and socio-ethical sustainability. Whereas Distributed economies are promising models for locally based and resilient sustainability. When coupled together and appropriately designed, they result in resilient solutions that could reduce the environmental impact with an economic benefit for the providers, while extending the access to goods and services to the low and middle-income contexts as well.
This book provides a comprehensive overview of the practice of designing Sustainable Product-Service Systems (S.PSS) applied to Distributed Economies (DE). It describes practical strategies, guidelines, and examples to support the design of environmentally, socially and economically sustainable Product-Service Systems. In addition, it presents strategies and guidelines enabling the design of Distributed Economies as Sustainable Product-Service Systems. Finally, it showcases the Method for System Design for Sustainability (MSDS) and its main tools, which are developed for designers to support the design of S.PSS and DE.

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Design of Sustainable Product-Service Systems (S.PSS) and Distributed Economies (DE)

Chapter 3:
Strategies, guidelines and examples to design S.PSS&DE

Chapter 4:
Method for System Design for Sustainability (MSDS)

Introduction

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 very model of development under discussion. In fact, we need to learn how to live better (the entire population of the planet!) and, at the same time, reduce our environmental footprint. In this framework the link between the environmental, socio-ethical and economic dimensions of sustainability can be clearly seen. Given the nature and the dimension of this change, we have to see 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. Therefore, a system-based approach is important in order to seriously tackle such a transition, suggesting the need for so called system innovations to take place. In this context, the two most promising models of Sustainable Product-Service System (S.PSS) and Distributed Economies (DE) have emerged as locally-based and (eventually) network-structured enterprises/initiatives. These models are particularly promising when they shift the offer focus

from selling products and equipment to offering (*a unit of*) *satisfaction*, i.e. new solutions through which needs and wants are met. If properly designed, they result in resilient solutions that could reduce the environmental impact, while extending the access to goods and services even to the low and middle-income contexts.

The scope of this book is to describe and support the practice of System Design for Sustainability (SDS), namely the design of Sustainable Product-Service System applied to Distributed Economies. By this we mean the *design of the Systems of Products and Services that are together able to fulfil a particular customer demand (deliver a "unit of satisfaction"), within the Distributed Economies paradigm; based on the design of innovative interactions among locally-based stakeholders, where the ownership of the product/s and/or its life cycle responsibilities/costs remain with the provider/s, so that the provider/s continuously seek environmentally and/or socio-ethically beneficial new solutions accessible to all with economic benefits.*

How is the structure of this book organized?

The first chapter introduces the meaning and implications of sustainable development, with a focus on the need for so-called system innovations. The second part of the chapter describes the evolution of design for sustainability towards system design approach for sustainability.

The second chapter introduces the promising models of Sustainable Product-Service System and Distributed Economies, as well as their coupling, i.e. S.PSS applied to DE. Followed by the introduction of the roles, approaches and skills required of the designer are introduced.

The third chapter is an overview on the practice of System Design for Sustainability, describing promising strategies with related guidelines and examples. The first part describes six strategies that help to orient the design towards environmentally and economically Sustainable Product-Service System; *system life optimisation, reduction of transportation and distribution, reduction of the resources use,*

waste minimization/valorisation, conservation/biocompatibility and reduction of toxic emissions. The second part of this chapter describes six strategies that aid in orienting the design towards socio-ethically and economically Sustainable Product-Service System; *improve employment/working conditions, improve equity and justice in relation to stakeholders, enable a responsible/sustainable consumption, favour/integrate the weaker and marginalized social strata, improve social cohesion and empower/valorise local resources.* The last part of this chapter describes the following six strategies enabling the design of Distributed Economies as Sustainable Product-Service System; *Complement DE hardware offer with Life Cycle services, Offer ownerless DE systems as enabling platform, Offer ownerless DE systems with full services, Optimise stakeholder's configuration, Delink payment from hardware purchases and resource consumption and Optimise DE structure.*

The fourth and last chapter presents the Method for System Design for Sustainability (MSDS) and its tools. MSDS has been developed for designers to support the design of S.PSS and DE.

This book is based on the work, studies and teaching activities of the *LeNSlab Polimi*, a research lab of the Design department of Politecnico di Milano, focused on Design and system Innovation for Sustainability research unit (DIS) and part of the *LeNS*[3], *the Learning Network on Sustainability*, an international network of universities. The method and tools, as well as the strategies/guidelines and the case studies, have been developed and improved in the course of more than 20 years, thanks to the support of some European Union-funded projects, specifically the following: (1) *MEPSS: Product Service Systems Methodology - Development of a toolkit for industry*, funded by the European Union, 5° Framework program. (2) *LeNS: The Learning Network on Sustainability. Network for curricula development on Design for Sustainability focused on Product-Service System*, funded by the European Union Asia Links; (3) *LeNSes. The Learning Network for Sustainable energy systems. Multi-polar and open network for curricula and lifelong learning capacity development on System Design for Sustainable Energy for All*

3 LeNS, Learning Network on Sustainability, is a worldwide network of design universities. Founded in 2007 and awarded by 3 EU-funded projects.

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Chapter 1 Sustainable development, system innovation and design

1.1 Sustainable development and system innovation

1.1.1 Sustainable development: a historical perspective

It was in 1987 when '*Our Common Future*', a key study by the United Nation (UN) World Commission on Environment and Development, was drafted to provide indicators regarding the future of humanity and the earth. This report was the first to define sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Herein, sustainable development refers to systemic conditions, where both social and productive development takes place:

- Within the capacity of the ecosystem to absorb the effects of human impact without causing any irreversible damaging effect, i.e. within limits of environmental ecosystem *resilience*[4];
- Using resources without compromising the ability of future generations to meet their own needs, i.e. preserving the *natural capital*[5],which will be passed on to future generations;

4 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.
5 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.

- Following the equity principle of equal redistribution of resources so that everyone has the same access to global natural resources, i.e. the same rights to *environmental space*[6].

6 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 briefly see how the concept of sustainable development has emerged and spread over time in the international scenario.

The impact of the production-consumption system on ecological equilibrium, defined as the *environmental issue*, began to rise in the second half of the 1960s, because of the acceleration and expansion of industrialisation. In 1972 the book *Limits to Growth* (Meadows et al., 1974) was published, being the first scientific forecast of a possible global ecosystem collapse as an effect of the ongoing system of production and consumption. The international debate about environmental issues spread during the 1970s and intensified further during the 1980s. Studies considered both the deterioration and the exhaustion of natural resources as an undesirable effect of industrial development and the increase of the world's population.

During the 1980s, while the pressure from public opinion escalated, governmental institutions took their first stand with a series of ecological norms and policies based on the *Polluter Pays Principle.*

In 1992 an historical event, the *United Nations Conference on Environment and Development* (UNCED), was held in Rio de Janeiro. Within which 178 UN member states ratified the Agenda 21; an action plan to build a global partnership for sustainable development to improve human lives and protect the environment.

In 2000 the *Millennium Summit* was organised by the United Nations in New York, where 189 UN member states ratified the *Millennium Declaration* to build a safer, more prosperous and equitable world. This resulted in the creation of 8 *Millennium Development Goals*; time-bound and measurable goals to be reached by 2015.

Fig. 1.1 The Millenium Development Goals (MDGs) by the United Nations

Such initiatives have provided a diffused integration of the concept of sustainable development into the reports of all international organisations.

Ten years after the Rio Conference the United Nations held the *World Summit on Sustainable Development* in Johannesburg (2002). At the end of the summit, the UN member states ratified the (non-binding) "Johannesburg Declaration " that laid out the Johannesburg Plan of Implementation to achieve the Millennium Development Goals.

Twenty years after the Rio Conference the United Nations once again held the UN *Conference on Sustainable Development 2012*, also known as Rio+20, in Rio de Janeiro. In this occasion 192 UN member states ratified the (non-binding) document *The Future We Want*, which stated (United Nations, 2012), "We the Heads of State and Government […] renew our commitment to sustainable development […] of an economically, socially and environmentally sustainable future for our planet and for present and future generations."

In 2015, the last United Nations *Agenda 2030 for Sustainable Development* was ratified, at the UN *Sustainable Development Summit* in New York. This was undertaken by 193 UN member states as a mutual commitment to global development, in favour of human well-being and to preserve the

environment. The main outputs of the Agenda are the 17 Sustainable Development Goals (SDGs), which gather the main challenges to be achieved by 2030. The 17 goals (United Nations, 2015) are listed below (and in Fig. 1.2):

- Goal 1: No poverty - end poverty in all its forms everywhere
- Goal 2: Zero hunger - end hunger, achieve food security and improved nutrition and promote sustainable agriculture
- Goal 3: Good health and wellbeing - ensure healthy lives and promote well-being for all at all ages
- Goal 4: Quality education - ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
- Goal 5: Gender equality - achieve gender equality and empower all women and girls
- Goal 6: Clean water and sanitation - Ensure availability and sustainable management of water and sanitation for all
- Goal 7: Affordable and clean energy - ensure access to affordable, reliable, sustainable and modern energy for all
- Goal 8: Decent work and economic growth - promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
- Goal 9: Industry, innovation and infrastructure - build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
- Goal 10: Reduced inequalities - reduce inequality within and among countries
- Goal 11: Sustainable cities and communities - make cities and human settlements inclusive, safe, resilient and sustainable
- Goal 12: Responsible consumption and production - ensure sustainable consumption and production patterns
- Goal 13: Climate action - take urgent action to combat climate change and its impacts
- Goal 14: Life below water - conserve and sustainably

use the oceans, seas and marine resources for sustainable development

- Goal 15: Life on land - protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
- Goal 16: Peace, justice and strong institutions - promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
- Goal 17: Partnerships for the goals - strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development.

Fig. 1.2 The 17 Sustainable Development Goals (SDGs) by the United Nations

The disparity of environmental impact produced by high, middle and low-income contexts and the pressing needs for social inclusion and the fulfilment of the basic needs for all, has been an important parameter for sustainable development approach throughout the UN's directives and policy orientation. Indeed, the necessary shift towards sustainability is presented as an opportunity for middle and low-income 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 Industrialized con-

texts, and for low-income contexts, developing dedicated solutions as the basis for sustainable growth.

In the framework of the 17 SDG's, the European Commission outlined their own strategies under the European Green Deal (EGD). The EGD provides an action plan to boost the "efficient use of resources by moving to a clean, circular economy and to restore biodiversity while cutting pollution" (European Commission, 2021).

1.1.2 The sustainability dimensions

It is common to schematise sustainability with three interlinked dimensions (United Nations, 2015):

- *Environmental protection (environmental dimension)*: not to exceed the "resilience" of the biosphere-geosphere, without provoking irreversible phenomena of degradation such as climate change, acidification, land use, etc.;
- *Social equity and inclusion (socio-ethical dimension)*: equal redistribution of resources following the principle that everyone has the same access to global natural resources, where key issues are both; the ability of future generations to meet their own needs and the achievement of social equity and cohesion;
- *Economic prosperity (economic dimension)*: promote inclusive and sustainable economic growth, employment, and decent work for all.

The characterising features of these three dimensions are described below:

The Environmental Dimension

The effects of the ongoing system of production and consumption on nature and the scientific forecast of a possible global ecosystem collapse have been studied since the 70s. Today we have clear information and scientific data testifying humankind's responsibility on the deterioration of the ecosystem and how damaging and dangerous the effects are.

The current ecosystem equilibrium would be disrupted by global warming in different ways.
Because of the global warming the area of the perennial Arctic sea ice has been steadily decreasing since the satellite record began in 1979. The Fig. 1.3 shows the annual Arctic sea ice minimum in 1979 and in 2021.

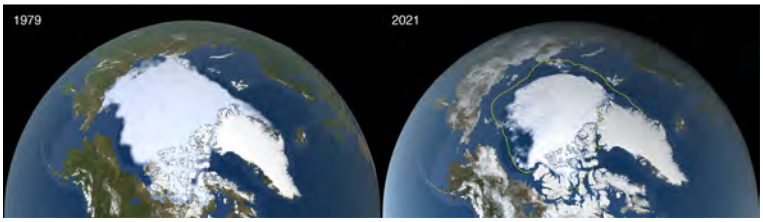


Fig. 1.3 The reduction of Arctic Sea ice minimum form 1979 and 2021 is shown and gives a clear idea of the consequences of global warming (NASA Scientific Visualization Studio 2021, www.climate.nasa.gov/vital-signs/arctic-sea-ice)

As one of the consequences, several areas of land would be submerged below water level (Seneviratne et al., 2021). The *Intergovernmental Panel on Climate Change* (IPCC)[7] estimated that global mean sea level will rise from a minimum of 0.28m (best-case scenario) to a maximum of 1.01m (worst case scenario) within the end of the century.
Extreme climate-related disasters, such as droughts, extreme temperature, floods, landslides, storms and wildfires are increased by global warming. Today the number of extreme climate-related disasters has more than doubled since the early 1990s (World Meteorological Organization (WMO), 2021) (see Fig. 1.4).

7 The *Intergovernmental Panel on Climate Change* (IPCC) has been established by the United Nations in 1988 to study and report on global warming.

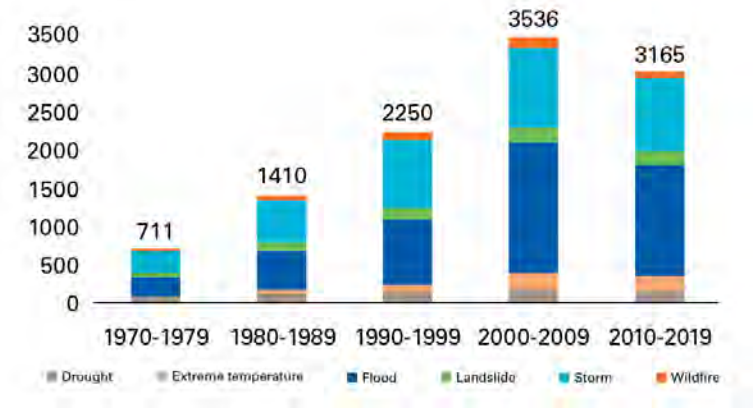


Fig. 1.4 Number of extreme climate-related disasters that took place in the past decades (World Meteorological Organization (WMO), 2021)

Furthermore, recent projections by IPCC (Intergovernmental Panel on Climate Change) show that the frequency of such events is likely to keep increasing in the next century, depending on different scenarios related to climate change (Masson-Delmotte et al., 2021).
However, climate change is not the only environmental damage caused by humankind. Let us have a look at some other significant issues.

The second prominent issue is that of air pollution (fine particles, O_3, NO_2, SO_2, CO, etc.), caused by human activity, which is dramatically rising. World Health Organisation has estimated that this causes 7 million premature deaths a year worldwide (World Health Organization, 2021).

Production and consumption systems also have a large impact on the extinction of various species. The health of ecosystems in which we, and all other species depend on, is deteriorating more rapidly than ever (IPBES, 2019). The *Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* (IPBES, 2019) estimated that 1 million animal and plant species are now threatened with extinction, more than ever before in human history (see Fig. 1.5). Current responses are rendered insufficient and truly transformative changes are needed to restore the ecosystems.

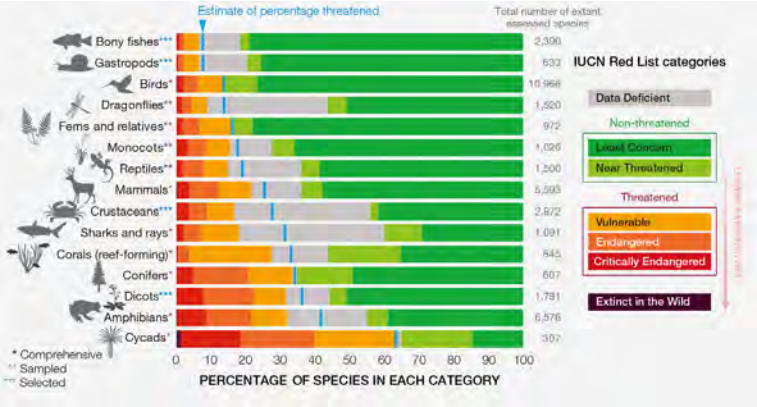


Fig. 1.5 Global extinction risk in different species groups (IPBES, 2019)

Furthermore, the quantity of waste generated by human activities keeps increasing at a higher rate. In 2016 2.1 billion tons of municipal waste was generated worldwide, i.e. 0.74 kg on average per person per day (Kaza et al., 2018). By 2025, without any change, this is expected to increase to a total of 3.4 billion (0.95 kg per person per day) tons of waste produced worldwide.
As to the ratio of plastic to fish (by weight) in the ocean today (2014), there is 1 kg of plastic for every 5kg of fish (World Economic Forum et al., 2016). At this pace, by 2025, this will increase to 1 kg of plastic for every 3 kg of fish and if there is still no change the mass of plastic in the ocean will outweigh that of the fish by 2050.

In 2021, the *Earth Overshoot Day* fell on July 29th (Global Footprint Network, 2021), i.e. the date on which humanity's resource consumption for the year exceeds Earth's capacity to regenerate them that year. This is the earliest ever calculated since 1970s. There is an overall difference of 153 days between 1970 and 2020.

In fact, some countries have a greater contribution than others; Fig. 1.6 shows when Earth Overshoot Day would occur if the world population lived like in many representative countries.

Fig. 1.6 Earth Overshoot Days in some countries (Global Footprint Network, 2021)

We introduced some of the damaging effects caused by the Human activity. Some other environmental effects are usually considered.

Regarding the ability of future generations to meet their needs we must consider the exhaustion of resources caused by their use (extraction), particularly of resources like water, minerals, and fossils; the non-renewable ones.

When considering the emissions of production and consumption systems, we take into account two categories of damaging effects: 1) the *ecological damages* of these emissions on the environment such as climate change (global warming) as seen earlier, acidification (terrestrial acid rain, ocean acidification), eutrophication (terrestrial, freshwater, marine), ecotoxicity (freshwater, marine, terrestrial, ionizing radiation) and land use (alteration of habitat, e.g. deforestation, urban development, agriculture, waste); 2) the *human damage* by resource emission such as the winter smog (particulate matter and inorganics air pollution) as seen earlier, summer smog (photochemical ozone formation, etc.), stratospheric ozone depletion and human toxic-

ity phenomena (cancer effects, non-cancer effects, ionizing radiation).

Observing the relations between the anthropic world and nature altogether, we can distinguish three fundamental *scenarios* of actions to reduce the environmental impact:

- **biocompatibility**, the scenario of the ***biological cycles***;
- **non-interference**, the scenario of the ***technical cycles***;
- **dematerialisation** scenario.

Biocompatibility, or the scenario of the ***biological cycles***, is where the resource/emission flows to produce goods and services are compatible with the natural system (the biosphere and the geosphere). This is done by using renewable resources and disposing off biodegradable and biocompatible emissions and waste.
In industrialised contexts, this scenario cannot cover several activities that must be faced, for which the following scenario can be highlighted.

Non-interference, or the scenario of the ***technical cycles***, is where resources/emissions are no longer drawn from nature, but remain (product/component life optimisation) or are reused (material life extension) in the technosphere, i.e. products' and components' life span is intensified (e.g. sharing) or extended through reuse, maintenance, repair, upgrade, remanufacture and/or materials are recycled, and energy is recovered.

The above two scenarios together describe what has been evolved in the last few years as the **Circular Economy**, defined as "an industrial economy that is restorative or regenerative by intention and design" (Ellen MacArthur Foundation, 2013). It is acknowledged by the European Union since 2014 as an economic system that "aims to maintain the value of products, materials and resources for as long as possible by returning them into the product cycle at the end of their use, while minimising the generation of waste" (European Comission, 2020).

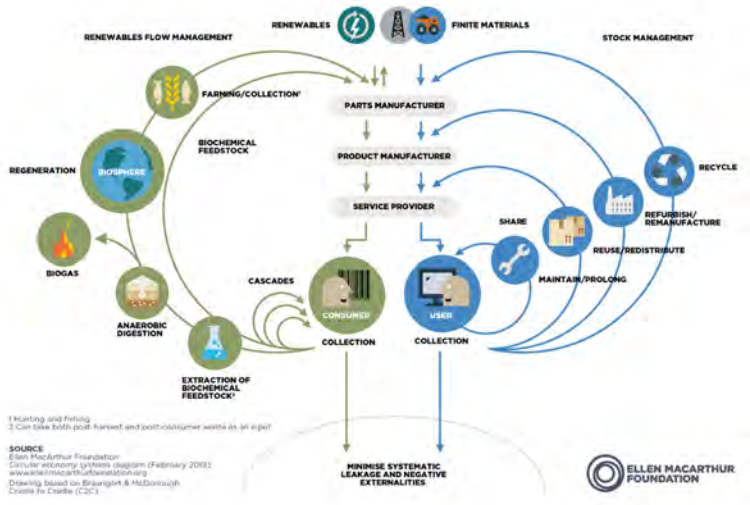


Fig. 1.7 The Circular Economy diagram representing biological and technical cycles (Ellen MacArthur Foundation, 2021)

Finally, we can imagine the scenario of the demand for well-being, **dematerialization**, where both input and output flows of resources/emissions are quantitatively diminished in relation to given social demand for needs and wants, satisfied by mixes of products and/or services.

The transition towards environmental sustainability will consist of a mix of these scenarios depending on the various conditions in different contexts.

The Socio-ethical Dimension

Promoting socio-ethical sustainability primarily means considering (according to the assumptions of the concept of sustainable development) the so-called *equity principle*, whereby every person has access to a fair distribution of resources.

Socio-ethical sustainability is not only a matter of eradicating poverty but more widely a matter of facilitating an improvement in quality of life and social cohesion, by "Fostering a high-employment economy delivering economic, social and territorial cohesion." Empowering people through high levels of employment, investing in skills,

fighting poverty and modernising labour markets, training and social protection systems so as to help people anticipate and manage change, and build a cohesive society." (European Commission, 2010).
In fact, when the issue of sustainable development crosses that of socio-ethical sustainability, the spectrum of implications and responsibilities extend to several issues such as (UN, 17 SDGs):

- Eradicate poverty and hunger in all its forms everywhere (see SDG 1, 2);
- Ensure healthy lives and promote well-being for all at all ages (see SDG 3);
- Ensure inclusive and equitable quality education for all (see SDG 4);
- Achieve gender equality and empower all women and girls (see SDG 5);
- Ensure access to energy, water and sanitation for all (see SDG 6, 7);
- Reduce inequality within and among countries (see SDG 10);
- Promote just, peaceful and inclusive societies (see SDG 16).

With regards to socio-ethical sustainability, a dominant issue is that of **eradicating poverty** and **hunger**. In 1996, in a summit organised by the UN's Food and Agriculture Organisation (FAO) in Rome, 185 member states agreed and committed to reduce the number of undernourished people by half. In 2000, the UN Millennium Summit adopted the Millennium Declaration where we can read (United Nations, 2000):"*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."

In the UN renewed action plan of the *Agenda 2030 on sustainable development* and its renewed Sustainable Development Goals, the new target regarding poverty is now to

"end extreme poverty in all forms by 2030". The SDG of "Zero Hunger" is based on the aim of ensuring that everyone, worldwide has access to nutritious food all year round by 2030.

In the report *The State of Food Insecurity in the World 2020* (FAO et al., 2021) states that, "Between 720 and 811 million people in the world faced hunger in 2020. Considering the middle of the projected range 768 million, 118 million more people were facing hunger in 2020 than in 2019 – or as many as 161 million, considering the upper bound of the range" (see Fig. 1.8).

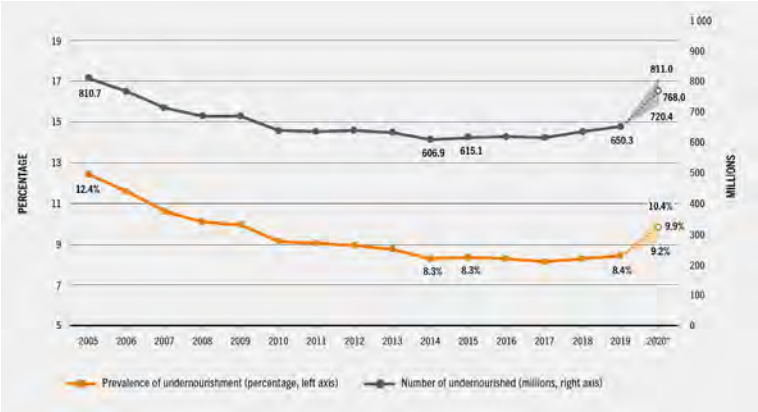


Fig. 1.8 Undernourishment in the World from 2005 and estimated rates for 2020 (FAO et al., 2021)

These numbers of people facing hunger in the world are unacceptably high. Majority of these live in a low-income and middle-income context. Fig. 1.9 shows how undernourishment increased the most in very low-income contexts, i.e. in Asia, Africa and Latin America. "[…] with less than a decade to 2030, we are not on track to ending world hunger and malnutrition – in fact, we are moving in the wrong direction." (FAO et al., 2021).

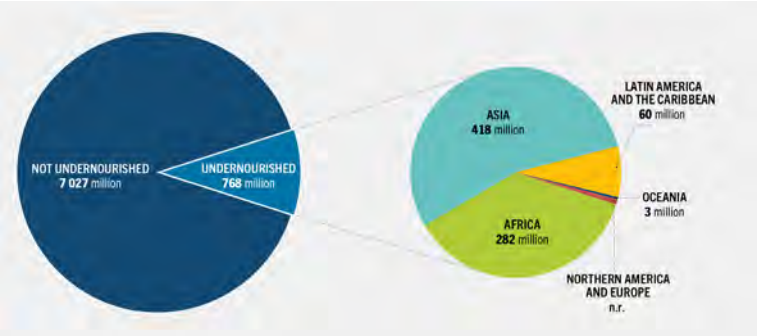


Fig. 1.9 Global undernourished population by different continent of the world (FAO et al., 2021)

Furthermore (FAO et al., 2021), "moderate or severe food insecurity[8] has been climbing slowly for six years and now affects more than 30 percent of the world population". Over half of the population in Africa, more than one-third in Latin America and in the Caribbean and more than one-fourth in Asia are food insecure.

8 An individual is considered to be living with food insecurity if they do not have reliable access to sufficient, safe, and nutritious foods that meet their dietary requirements and preferences.

The Economic Dimension

The economic dimension of sustainability engages us in promoting environmentally and socio-ethically sustainable models of production and consumption, while being economically feasible and fostering economic prosperity.
Three main *scenarios* could be drawn regarding this dimension:

- *internalisation of costs;*
- *orientating the main ongoing transitions towards sustainable solutions;*
- *enhancing promising niche economic models.*

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 accounted for in the purchasing price but are a cost for the society nonetheless. Furthermore, indirect costs appear when resources are embedded in and/or used by the products, generating environmental and economic costs during their life cycle. For example, the producer and the user of a car (product

consuming resources and that have emissions during the use stage) pay truly little of the indirect health costs paid by society when people contract illnesses due to the emissions of the car during the use phase. The **internalization of costs** means to embed all the direct and indirect costs in the purchase cost of a good or service, in order to encourage innovation towards the minimisation of environmental impacts. The producer of a car should sell the existing car (determining air pollution during the use phase) with a much higher cost compared to the current cost, rendering it unaffordable for many users; and thus economically incentivising the manufacturers to develop innovative cars with lowest environmental impact even during the use phase. In other words, we should move towards a proper attribution of costs, where internalisation of costs is mainly a political and legislative issue.

Another strategy is to **orient the main ongoing transitions** (transitions regarding interconnection, globalisation, information, services, etc.) towards sustainable solutions. An example to illustrate this would be exploiting the dematerialisation potential of new ICT and e-mail systems as compared to the traditional postal system. It can be argued that reorientating can produce considerably more effective results than attempting to go back in time and return to former production-consumption models.

Finally, it is important to promote and **enhance promising economic models**, wherein they are currently only with **niche** market share. Some promising models fitting into the frame of environmental, socio-ethical and economic sustainability have been studied, such as, *Sustainable Product-Service Systems and Distributed Economies*[9].

9 These promising models are described in the next chapters.

1.1.3 Call for a Radical Change and System Innovations, now!

During the 1990s, a series of studies and analyses led to a better understanding of the magnitude of change necessary to achieve a sustainable society for all (Stahel, 1997).

Since then, we know that conditions for sustainability can only be achieved by drastically reducing both the extraction of environmental resources and the emissions released back to the geosphere and biosphere, as compared to the (average) production and consumption systems of mature industrialised societies.

Considering demographic growth forecasts and an increase in the demand for well-being in currently disadvantaged contexts, in 50 years, conditions for sustainability are achievable only by increasing the efficiency of the industrialised production-consumption system by a factor of ten. In other words, considering the equity principle, by 2050 the production and consumption systems in industrialised contexts should use 90% less resources than they are doing today[10].

In the 1970s the goal was to slow down before hitting the environmental limits, now the goal is to get back down below the limits without severe damage to the earth. To illustrate the same, if the current trends of overfishing and pollution continue, all seafood would face collapse by 2048. Also, by the middle of the 21st century, 7 billion people in 60 countries may face water scarcity. Some authors have started to say that we are close to the collapse of the eco-systems.

These estimates are significant enough to indicate the scale of the change that should take place. A radical transformation in our development model is necessary, and sustainable production and consumption systems will be significantly different from what we have been taking for granted up to now. The transition towards a sustainable society requires radical changes in the way we produce, consume and more in general, in the way we live. Sustainability necessarily places the same model of development under discussion. How this may happen is at present not easy to foresee. Nevertheless, it is certain that there will have to be a system discontinuity that will affect all facets of the societies. Given the nature and the dimension of this change, we must see transition towards sustainability as

10 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 for Improved Economic and Environmental Performance" by WBCSD, 1996).

a wide-reaching social learning process in which system discontinuity is needed. And we must act **now!**

When taking this to the design and development level, it is clear that what is requested is a system innovation approach (Kemp & Rotmans, 2004; Geels, 2006; Frantzeskaki & Haan, 2009; Vezzoli et al., 2014; Ceschin & Gaziulusoy, 2019).
At a system innovation we go beyond product innovation, towards the innovation of the system of products and services capable of fulfilling a given unit of satisfaction, as well as the innovation of the stakeholder configuration.
Within the wide debate on how to approach and foster system innovation, the offer model of Sustainable Product-Service Systems (S.PSS)[11] and Distributed Economies[12] appear as promising to couple environmental, socioethical and economic sustainability.

11 This type of innovation is described in the chapter 2.1
12 This type of models are described in chapter 2.2

1.2 Evolution of design for sustainability

1.2.1 An increasingly recognised role for design

Since the second half of the last century, the reaction of humankind to environmental degradation, has moved from an *end-of-pipe* approach to actions increasingly aimed at *prevention*. Actions and research focused exclusively on the de-pollution of systems have shifted towards research and innovations aimed to reduce the cause of pollution at source. More precisely over time the changes have been from: (a) intervention after process caused damages, to (b) intervention in processes, to (c) intervention in products and services, to (d) intervention in consumption patterns and offer model.

Given this progress, it is evident that the role of design for environmental sustainability has expanded over time. In fact, the emphasis shifts from end-of-pipe controls and remedial actions to prevention. The emphasis further expands from isolated parts of the product life cycle (i.e. only production) to a holistic product life cycle perspective. Finally, the emphasis passes further into the sociocultural 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; and the emphasis widens towards enabling users' alternative and more sustainable lifestyles.

In fact, Design for Sustainability has been recently recognized within the international institutional context as one of the key disciplines to foster sustainability, e.g. as reported within the "Circular Economy Action Plan" approved and published by the European Community in 2020 (European Commission & Directorate-General for Communication, 2020)

"Up to 80% of products' environmental impacts are determined at the design phase. […] The core of this legislative initiative will be to […] make the Ecodesign framework applicable to the broadest possible range of products". […] "Incentivising product-as-a-service or other models where producers keep the ownership of the product or the responsibility for its performance throughout its lifecycle".
This is to say that even up to the top level of Political commitments, the fundamental role of design is clear to promote a sustainability. Furthermore, clear is the need to change the same offer model.

1.2.2 Evolution of design for sustainability

The discipline of **Design for Sustainability** 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.[13]
Design for Sustainability has enlarged its scope and field of action over time, as observed by various authors (Madge, 1993; Vezzoli et al., 2018a; Ceschin & Gaziulusoy, 2019). The focus has expanded from the selection of ***resources*** with low environmental impact to ***product*** design for environmental sustainability, to ***system*** design sustainability, going beyond product innovation and aiming at both environmental protection, social inclusion and economic

13 Some authors adopt a more stringent definition of Design for Sustainability. Tischner (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).

prosperity.

The first two books introducing environmental and social considerations into the design world are generally considered to be *Design for the Real World: Human Ecology and Social Change* written by Victor Papanek in 1972 (Papanek, 1985) and *La Speranza Progettuale: ambiente e società* (The Design Hope: environment and society) written by Tomas Maldonado in 1971 (Maldonado, 1971). The books provided a concern of the design profession, pointing out its role in encouraging consumption and therefore contributing to environmental and social degradation.

Since the 90s, a new knowledge-base and know-how started to be developed to the design of products for environmental sustainability, i.e., with low environmental impact. The Design Council published in 1991 in UK the book Green Design (Burall, 1991) and the Environmental Protection Agency published in 1992 in U.S. the text *Life Cycle Design Guidance Manual: Environmental Requirements and the Product System* (Keoleian & Menerey, 1992).
The attention was initially focused on redesigning individual qualities of products, e.g. *design for recycling, design for disassembly, design for remanufacturing, toxicity minimisation*. In the second half of the 90s, the design approach broadened to address the entire product life cycle, from the extraction of resources to the product disposal. Few terminologies started to be used, such as ***product Life Cycle Design, Ecodesign*** or ***product Design for Environmental Sustainability***. In those years, the environmental effects attributable to the pre-production, production, distribution, use and disposal of a product and how to assess them became clearer and new methods and tools to assess the environmental impact (of products) were developed; the most accepted being Life Cycle Assessment (LCA)[14]. In particular, the following two approaches were introduced: 1) the life cycle approach: to design 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 it of are considered; 2) the functional approach: to design and evaluate a product's environmental sustainability,

14 Life Cycle Assessment 'addresses the environmental aspects and potential environmental impacts 2) (e.g. use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal (i.e. cradle-to-grave).' ISO 14040 (2006) and ISO 14044 (2006).

considering its function rather than from the physical embodiment of the product itself.
Since the late 90s design research also started to look at nature as a source of inspiration to address sustainability. ***Cradle to Cradle (C2C) design*** is one of these approaches, whose main principle *waste equals food* focuses on creating open loops for *biological nutrients* and closed loops for *technical nutrients*. As far as C2C is focused on the products' flow of material resources, this might result in overlooking some other environmental aspects (e.g. energy consumption in the use phase).
Since late 1990s interest has risen in adopting nature as a model for achieving sustainability through design; the approach has been called ***biomimicry***, which studies the materials and processes of nature as an inspiration for design.
Some authors (Ceschin & Gaziulusoy, 2019), highlight that product Life Cycle design focuses on a technical perspective, with limited attention to the human-related aspects.
Since the late 90s, ***emotionally durable design*** focuses on the user-product emotional connection and proposes design strategies to strengthen that connection in order to extend product lifetime. While ***design for sustainable behaviour***, focus on how design can influence users to adopt a desired sustainable behaviour and abandon an undesired unsustainable behaviour.
In the second half of the 2000s, some ***design*** researchers started to address low-income people and communities, the so-called ***Base of the Pyramid*** (*BoP*[15]), i.e. the social aspects of sustainability.

15 The BoP is the poorest portion of the global population who live with an annual income below a certain Purchasing Power Parity (PPP) threshold.

Since the late 90s we started to realise that a more stringent interpretation of sustainability requires radical changes in production and consumption models, so forth system innovations, from a design perspective a shift from product design thinking to system design thinking.
For this reason, attention has moved to ***design for Eco-Efficient Product-Service Systems***, mixes of products, services and networks (configuration) of actors need to be designed simultaneously, giving way to new offer and organisational models through which needs and wants are met (UNEP, 2002). Some design researchers argued that the

design conceptualization process needs to expand from a purely functional approach to a satisfaction approach. 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, a *unit of satisfaction approach* started to be proposed (Vezzoli, 2007).

Other design researchers have proposed to adopt a territorial approach, looking at local socio-economic actors, assets and resources with the goal of creating synergistic linkages among natural and productive processes. This approach has been labelled as systemic design, and seeks to create complex industrial systems, where material and energy flows are designed so that output from a socio-economic actor becomes input for another actor.

Some other researchers speculated on ***design for social innovation and sustainability*** (Meroni, 2007; Jégou & Manzini, 2008) by adopting a bottom-up approach and investigating so-called 'Creative communities', i.e. how people and communities (sometimes in collaboration with other local institutions, organisations and entrepreneurs) innovate and design, implement and manage social innovations. Typical examples of social and sustainable innovation include community car-pooling systems, food networks linking consumers directly with producers, new forms of exchange and mutual help, etc.

An emerging design research area is ***design for sustainability transitions*** (Vezzoli et al., 2008; Ceschin & Gaziulusoy, 2019) focusing on the transformation of socio-technical systems through technological, social, organisational and institutional innovations. Design for sustainability transitions expanded its focus from businesses and production–consumption systems to cities, which are essentially systems of socio-technical systems.

After an initial emphasis on product design the design research focus on the BoP has moved to Product-Service System design (UNEP, 2002; Vezzoli, 2010; Schafer et al., 2011; Santos et al., 2014; Vezzoli et al., 2021) and social entrepreneurship and innovation.

Other researchers studied and developed new knowledge in relation to ***Sustainable Product-Service Systems (S.PSS) design*** coupling economic and environmental benefits with

social equity and cohesion, namely extending the access to good and services to low-income contexts.
Since 2005 ***Distributed Economies*** have been studied as locally-based and resilient sustainability opportunities. Distributed Economies are defined as small scall production unit nearby or by the end user, eventually connected in local network.
Finally, a new design role has been studied and defined to ***design Sustainable Product-Service System applied to Distributed Economies*** (Vezzoli et al., 2021; Vezzoli et al., 2018b).

1.2.3 State of the art of design for sustainability

Looking at the evolution of Design for Sustainability, the following considerations can be made.
First, Design for Sustainability shows a widening in its scope. In fact, DfS has broadened its theoretical and practical scope progressively expanding from materials/resources selection to single product innovation, to system innovation. From tackling the environmental dimension, to economic and socioethical ones.
Second, an increased focus on the *people-centred* aspects of sustainability could be observed. In fact, the first DfS approaches have mainly focused on the technical aspects of sustainability. While, more recent approaches have recognised the crucial importance of the role of users, communities and social dynamics in socio-technical systems.
Finally, a consideration can be made on the importance of each DfS approach. Even if it is true that sustainability must be addressed at a system level, this does not mean that the approaches focusing on the resource selection or product innovation levels are less useful. Any new socio-technical systems are anyhow characterised by a material and product dimensions that needs to be appropriately designed. Thus, each DfS approach is equally important because addressing sustainability challenges requires an integrated set of DfS approaches spanning various innovation levels.

Chapter 2 Design of Sustainable Product-Service Systems (S.PSS) and Distributed Economies (DE)

2.1 Sustainable Product-Service Systems: win-win opportunities for sustainability

Sustainable Product-Service System (S.PSS) has been studied since the end of the 90s as one of the most promising offer/business models coupling the environmental and economic sustainability. More recently, they demonstrate to be one of the most promising offer models to extend the access to goods and services even to low and middle-income contexts, so forth enhancing social equity and cohesion. Finally, a win-win offer model combining the three pillars of sustainability, the economic, the environmental and the socio-ethical (see more details on Vezzoli et al., 2021).

A **Sustainable Product-Service System (S.PSS)** is defined as follow (Vezzoli et al., 2021):

"an offer model providing an integrated mix of products and services that are together able to fulfil a particular customer/user demand (to deliver a "unit of satisfaction"), based on innovative interactions between the stakeholders of the value production system (satisfaction system), where the ownership of the product/s and/or the life cycle services costs/responsibilities remain with the provider/s, so that the same provider/s continuously seek/s

environmentally and/or socio-ethically beneficial new solutions, with economic benefits".

Three majors S.PSS approaches to system innovation have been studied and listed as favourable for win-win for environmental, social and economic sustainability (Goedkoop et al., 1999; Van Halen et al., 2005; Vezzoli et al., 2021):

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

A **Product-oriented S.PSS** innovation adding value to the product life cycle is defined as:

"a company/organization (alliance of companies/organizations) that provides all-inclusive life cycle services – maintenance, repair, upgrading, substitution and product take-back – to guarantee the life cycle performance of the product/semi-finished product (sold to the customer/user)".

A **use-oriented S.PSS** innovation offering an enabling platform to customers is defined as:

"a company/organization (alliance of companies/organizations) that provides access to products, tools and opportunities enabling the customer to get their "satisfaction". The customer/user does not own the product/s but operates them to obtain a specific "satisfaction" (and pays only for the use of the product/s)".

A **result-oriented S.PSS** innovation offering final results to customers is defined as:

"a company/organization (alliance of companies/organizations) that offers a customized mix of services, instead of products, in order to provide a specific final result to the customer. The customer/user does not own the products and does not operate on them to obtain the final satisfaction (the customer pays the company/organization to provide the agreed results)".

A S.PSS is eco-efficient when the product ownership and/or the economic responsibility on its life cycle performance remain by the producer/providers who is selling a unit of satisfaction rather than (only) the product.
Why does this happen? Because we shift/allocate the liability, on the stakeholder responsible for the products and/or the services design/development, reducing environmental impact, which is driven by their direct economic and competitive interests.
Finally, within an S.PSS model a product LCD/eco-design is eco-efficient.

An S.PSS may foster as well socio-ethical benefits because S.PSS make goods and services accessible and preservable over time to both final user and entrepreneurs/organisations even in low and middle-income contexts.
An S.PSS model the producer/provider has an economic interest in design for social inclusion, i.e., to extend sustainable access and use of products/equipment to low- and middle-income people.

It is important to underline that not all shifts to economically beneficial PSS result in environmental and socio-ethical benefits: a PSS must be specifically designed, developed and delivered, if it is to be highly sustainable.

2.2 Distributed economies (DE): a promising model for locally-based and resilient sustainability

Studied since the second half of 2000s, **Distributed Economies** are now defined as (Vezzoli, 2021):
"small-scale production units, shifting the control on essential activities towards or by the end-user, whether individuals, entrepreneurs or organisations, i.e. there are no intermediaries, or the producers are the same end-users. The production unit could be standalone or network-structured with other DE units to share various forms of products, semi-finished products, resources and/or services, i.e. they become a Distributed Economy Network (DEN), which may in turn be connected with similar networks".

We may identify the following types of Distributed Economies (DE), organised in two groups: hardware/natural resources-based DE and knowledge/information-based DE (Vezzoli, et al. 2021):
Hardware/ natural resources-based DE:

- Distributed energy Generation (DG),
- Distributed Food production (DF),
- Distributed Water management (DW)
- Distributed Manufacturing (DM).

Knowledge/information-based DE:

- Distributed Software development (DS),
- Distributed Knowledge generation (DK),
- Distributed Design (DD).

As far as Distributed Economies (DE) make local DE stakeholder directly interested to safeguard the environment and the availability of resources in the context in which they live/work, they represent opportunities to promote locally-based environmental benefits.

As far as Distributed Economies (DE) give to local users the direct access to resources and increase local participation for the extraction, production, use and disposal (of such resources), they represent opportunities to promote locally-based socio-ethical benefits.

It is at this point important to remark that not all DEs are sustainable, but if properly designed they are promising to promote locally-based sustainability and resilience, i.e. *Sustainable Distributed Economies (S.DE)*.

Recently the application of S.PSS to DE, have been studied (Vezzoli et al., 2021) as promising approach to promote and diffuse locally-based sustainability and resilience, with both environmental, socio-ethical and economic benefits:
"S.PSS is a promising approach to diffuse DE in low/middle-income (all) contexts, because it reduces/cuts both the initial (capital) cost of DE product/equipment purchasing (that may be unaffordable) and the running cost for maintenance, repair, upgrade, etc. of such DE hardware (that may cause the interruption of use) increasing local employment and related skills. Furthermore, by offering a DE system adopting an S.PSS model, the producer/provider is economically incentivized to design low environmentally impacting DE products/equipment. Finally, S.PSS applied to DE is a promising key leverage for a sustainable development process for all aiming at democratizing access to resources, goods and services".

2.3 Designing S.PSS applied to DE

As introduced in the previous chapter, S.PSS applied to DE can be assumed to create an opportunity for a locally based and sustainably resilient economy for all. Consequently, a new role for designers has been envisioned and studied (Vezzoli et al., 2021):
Designing Sustainable Product-Service System applied to Distributed Economies, or shortly **System Design for Sustainability for All (SD4SA)**, that we may define as follow:

"the design of Systems of Products and Services that are together able to fulfil a particular customer demand (deliver a "unit of satisfaction"), within the Distributed Economies paradigm; based on the design of innovative interactions among locally-based stakeholders, where the ownership of the product/s and/or its life cycle responsibilities/costs remain with the provider/s, so that the provider/s continuously seek environmentally and/or socio-ethically beneficial new solutions accessible to all with economic benefits".

Based on the foundations of S.PSS design (Vezzoli et al.,

2014; Van Halen et al., 2005; Tischner, Ryan and Vezzoli, 2009; Vezzoli et al., 2021), the following approaches and skills can be identified for a designer approaching System Design for Sustainability for All (SD4SA):
(a) "Satisfaction-system" approach: this calls for skills to design the system of products and services that, within a DE paradigm, can satisfy a particular demand ("satisfaction unit");
(b) "Stakeholder configuration" approach: this calls for skills to design the stakeholders' interactions in a particular DE satisfaction-system;
(c) "System sustainability4all" approach: this calls for skills to design-for-all a DE system where the providers continuously seek environmental and/or socio-ethical beneficial new solutions, with economic benefits.

A set of strategies and guidelines, and the Method for System Design for Sustainability (MSDS) with its tools, have been developed to support the design of S.PSS applied to DE[16]. It is important to note that in order to allow methods and tools to be assessed, adapted and improved, experimentation, both in applied research projects and in teaching, has been fundamental and will continue to be so in future.

16 The MSDS with its tools, as well as the strategies/guidelines, have been developed and improved in European Union-funded projects, specifically the following: *MEPSS: Product Service Systems Methodology; LeNS: The Learning Network on Sustainability; LeNSes. The Learning Network for Sustainable energy systems; LeNSin: The Learning Network of Networks on Sustainability.*

Chapter 3 Strategies, guidelines and examples to design S.PSS&DE

It has been already observed that neither every Product-Service System nor every Distributed Economy (DE) is environmentally, socio-ethically and economically sustainable. Accordingly, is of key importance to adopt appropriate strategies and guidelines (as well a method and tools embedding them[17]), when designing new Product-Service Systems (with the potentialities to be radically sustainable), that would steer it towards an environmentally, socioethically and economically sustainable solutions.

17 See the chapter 4

In this chapter we present the strategies, the guidelines[18] and some examples to orient the design towards:

18 Those strategies and guidelines are in fact embedded in some tools that are presented in chapter 4.2.2.

- Environmentally sustainable PSS;
- Socioethically sustainable PSS;
- S.PSS applied to DE.

These are described in the next three paragraphs.

3.1 Strategies, guidelines and examples to design environmentally sustainable PSS

The producer/provider is not always driven by economic interests towards the development of environmentally beneficial PSS. As adopted by the LeNS network, six strategies can be listed according to their orientation towards environmental sustainability (updated from Vezzoli et al., 2014)[19]:

- System life optimisation;
- Transportation/distribution reduction;
- Resources reduction;
- Waste minimisation/valorisation;
- Resources conservation/biocompatibility;
- Toxicity reduction.

19 The strategies were firstly developed in the European research project entitled MEPSS, Method for Product- Service System development, funded by EU, 5FP, Growth (van Halen, Wimmer, Vezzoli, 2005).

There are interrelations between such environmentally sustainable strategies (and related guidelines that are presented in the following), meaning that for a given *satisfaction system*, some strategies (and related guidelines) have higher relevance than others. Therefore, in a decision-making process (designing) it is important to identify the environmentally sustainable design priorities; namely the

relative relevance of the strategies per the system that need to be re-designed, i.e., the most promising strategies and related stakeholders' interactions guidelines.
In the following paragraph the six strategies are presented together with guidelines and case studies as examples (of the same guidelines).

System life optimisation

When speaking about system life optimisation, we mean the design for system stakeholder's interactions leading to extending the sum of the product's life span and intensifying the sum of the product's use.
A product with longer lifespan than another similarly functioning one, generally determines smaller environmental impact. A product with accelerated wear will not only generate untimely waste but will also determine further impact due to the need to replace it (see Fig. 3.1). Production and distribution of a new product to replace its function involves the consumption of new resources and the further generation of emissions.

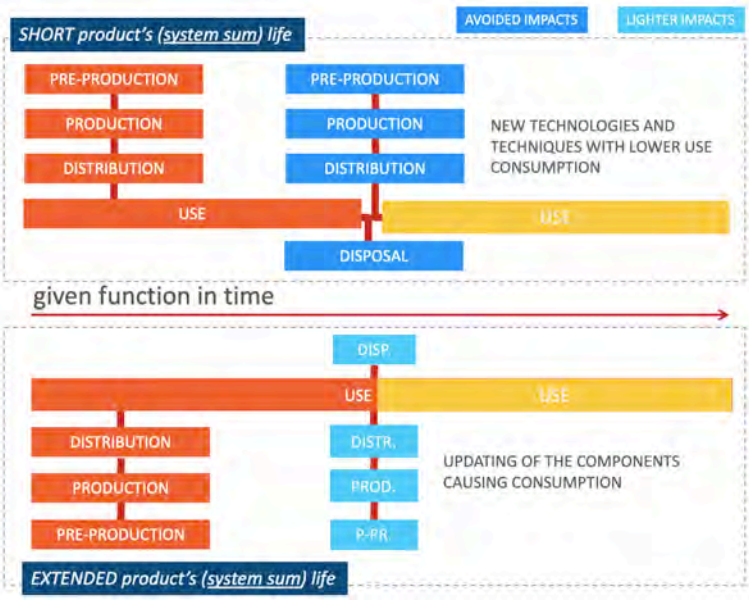


Fig. 3.1 Environmental advantages of a product (system sum) with a longer lifespan

But regarding to the given product in use, the extension of its lifespan might not determine a reduction in impact; continuing to use an old product can even cause an increase in impact. When technological development offers the opportunity to have new products with better environmental effectiveness (e.g., lower consumption of energy or materials or reductions in emissions) providing the same exact service, then soon the need to manufacture, distribute and dispose the new product is compensated. Balancing the environmental impact, by improved performance in use. However, the duration of products can be planned by increasing their reliability and facilitating updating, adaptability, maintenance, repairs, re-use and re-manufacturing. Finally, from a system perspective we must consider the overall and interlinked avoided (or eventually added) environmental impacts of the product's system or its ancillary products, needed for the satisfaction of a certain demand of needs and desires.
Let's look at the environmental advantages of intensifying the usage of the product. The figure 3.2 depicts a product that is shared and used intensively by Andrew in the periods A1, by Bernard during the periods B1, and finally by Charlie at the periods C1. Below we have the timeline with the same service rendered from 3 different products, each one used by the three aforementioned people. One item is pre-produced, produced, distributed for Andrew and then used by him, another one for Bernard and finally third one for Charlie. In the figure the avoided impacts of an intensively used product are highlighted in blue.

This reasoning is valid as far as life span is not dependent by the length of use, i.e., for those products that are disposed because they appear obsolete though not worn out.
Let us consider then even the case in which the life span is dependent from the length of use. The same situation we saw before is reported in figure 3.3, but now the below products used less intensely last longer. If we want to compare the two scenarios, we should consider the pre-production, production, distribution, the use and disposal of another product, when the first is disposed that is used for the same periods. And then of another product when the

second is disposed.

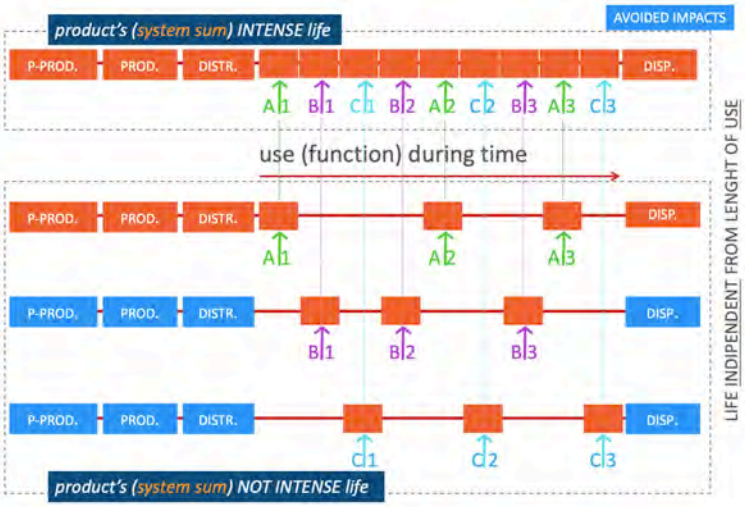


Fig. 3.2 Environmental advantages of intensifying the usage of the product's system sum (lifespan not dependent on the length of use)

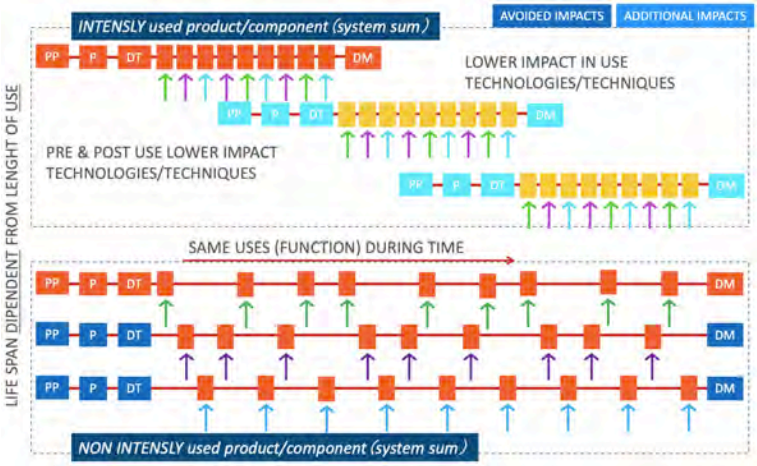


Fig. 3.3 Environmental advantages of intensifying the usage at home of the product (life span dependent by the length of use)

In qualitative terms to understand whether an existing system of product and services presents problems related to life optimisation, the following key questions should be

asked:

- Are disposable systems used?
- Are disposable products packaging or support products used?
- Do parts of the system tend to be technologically obsolete?
- Do parts of the system tend to be culturally/aesthetically obsolete?
- Do some parts of the system tend to wear out more easily (than others)?

Guidelines for system life optimisation

- Complement products/infrastructures with all-inclusive services for maintenance, repair, substitution. **examples 1**
- Complement products/infrastructures with services for technological upgrade. **example 2**
- Complement products with services for aesthetical/cultural upgrade.
- Complement products/infrastructures with services that enable their reconfigurability, e.g. adaptation in new location. **example 3**
- Complement product/infrastructure with all-inclusive take-back services aimed at re-using or re-manufacturing. **example 4**
- Offer services for shared use of ownerless products/infrastructures, e.g. pay-per-period, pay-per-use. **examples 5**
- Offer services for shared ownership of a set of products, e.g. collective purchase and use of products by multiple users.
- Offer services for sharing and/or exchange of products. **examples 6**
- Offer infrastructure/services for product reuse and second hand selling by providing infrastructures (e.g. collection points, product cleaning) or platforms (e.g. online marketplace of used products). **example 7**

examples

1.1. Aeron by Herman Miller - office chair with 12 years warranty

Fig. 3.4 Left: Aeron chair; Middle and right: Easily assembly and disassembly based on four screws and a single screwdriver[20]

20 Herman Miller (2022). photographer: Graham Morgan

Aeron and other chairs sold by Herman Miller have a 12-year warranty. During the warranty period, Herman Miller, repairs or replaces (at its option, without any additional cost) any product, part, or component which fails because of a defect in material or workmanship, with a comparable product, part, or component. Thus, Herman Miller is interested in extending the product's lifespan by designing office furniture and its components to be easily repaired or replaced.

1.2 Pay Per Page Green – Ricoh

Ricoh is a copy machine and printer manufacturer that some years ago moved towards an S.PSS model called Pay Per Page Green. Instead of selling, they offered high-quality machines charging a fee "per page", that was calculated through a preliminary analysis of client consumption and checked with self-monitoring software installed on printers. Moreover, they offered life cycle services like installation, repair, maintenance, substitution of consumables and disposal. Thus, Ricoh profit was coupled with products durability and efficiency. Ricoh Pay per Page Green extended considerably the lifetime of printers, thanks to the combination of products and services designed to facilitate maintenance, repair, remanufacturing, reuse. In particu-

lar, a self-monitoring software coupled with maintenance provided by the company helped to keep printers in good performing conditions. At the end-of-life, components were tested, and functional parts were re-manufactured or directly reused in a new printer. Ricoh products were designed to allow component compatibility between different models and to facilitate the whole processes of re-using or remanufacturing.
Furthermore, damaged components were directed to material recycling. Given that ownership of printers was retained by Ricoh, designing for product lifespan extension allowed to avoid/postpone costs for new printers' pre-production, production, distribution and disposal.

1.3 Furniture as a service

Gispen is an office furniture manufacturer that provides FAAS (furniture as a service) solution to users.
FAAS is a subscription, which leases office furniture and service for a fixed monthly fee. Gispen keeps the ownership of furniture.
With FAAS, Gispen provides well-designed furniture (suitable for refurbishing and remade) with all-inclusive services for maintenance (annual check-ups, regular cleaning), repair, upgrades, replacement, reconfiguration when the users' needs change.
Customers pay per period of use and avoid costly fees for services. Since the ownership is retained by Gispen, it is economically beneficial for the company to design for furniture system life extension. Furthermore, the company is as well incentivised to design for material life extension (waste minimisation/valorisation).

2. Washing machine with fuzzy logic and update – Miele

The German brand Miele produces a series of washing machines (in this particular case, we refer to the WEG665 WCS) equipped with a system which can "read" the load of clothes and their textiles, subsequently dosing the washing powder and using adequate washing programs. The system can modify these programs after updating the da-

tabase recorded inside the computer, making possible the use of innovative products, whether detergents or textiles. The update function postpones technological obsolescence and extends serviceable life. The washing machine is sold together with the service, that is included in the WiFi-connect package and that can be accessed by the user through a smartphone app.

3. Take Back Service - Rype Office

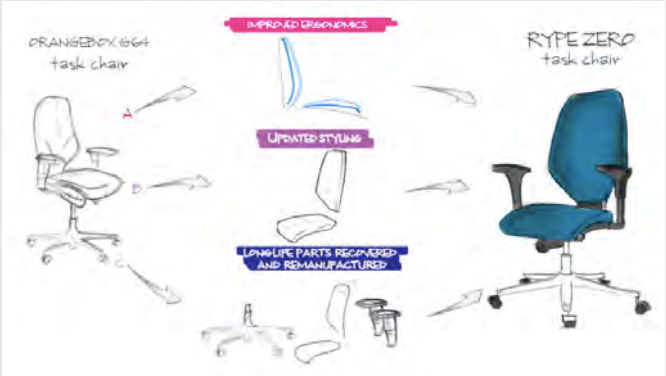


Fig. 3.5 Development process after taking back furniture[21]

21 Rype office (2022). Retrieved from: https://www.rypeoffice.com/rype-zero/

Rype Office is a UK-based furniture producer who specializes in designing and remanufacturing office furniture. They complement remade furniture with take-back services aimed at reuse and remanufacturing, and reconfigurability which will extend the system life.
Together with furniture, Rype office provides all-inclusive office layout and interior designs to integrate remade furniture with existing surrounding and create space-efficient, comfortable and productive workspaces, i.e. enabling their reconfigurability and adaptation in new location.
With a fixed fee for furniture, Rype office provides delivery and installation services.
This offer extends the lifespan of furniture/component and reduces end of life waste. It is economically beneficial for Rype office to design for furniture remanufacturing. For users, especially SMEs, this model reduces the initial investment purchasing furniture costs.

4. Desso – Carpet tiles leasing

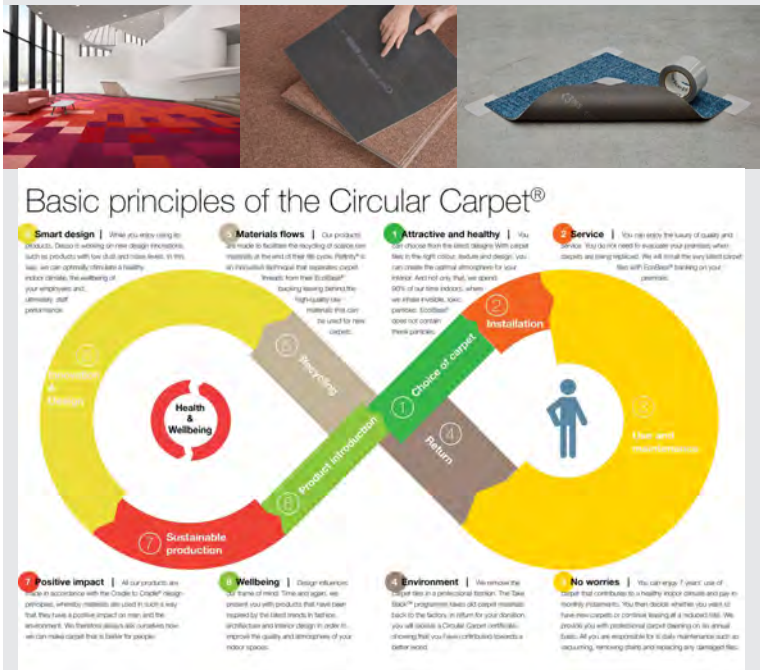


Fig. 3.6 Top Left: typical Desso modular design[22], Middle: sample of modular tiles[23] Right: sample of tile sticking technology to facilitate punctual maintenance[24]; bottom: Circular carpet process implemented by Desso[25]

Desso Commercial Carpets is a global carpet and carpet tiles company that works for commercial customers from different sectors. Among their solutions, they provide the Carpet Leasing Service, which is based on turning carpet tiles into a service: Desso keeps the ownership of products and provides installation, cleaning, maintenance and eventually removal. Moreover, after the standard 7-years contract, a new carpet is provided by Desso and the old one is recycled and reintegrated into a new life cycle. Carpet Tiles Leasing allows to extend the overall flooring lifetime through a design oriented toward maintenance and repair. Differently from rolls, tiles are designed to be modular and easily removable (each tile is sticked through tape and can be punctually removed) and this allow to avoid a complete renovation of the flooring. Moreover, since Desso doesn't sell the tiles, the company provide services like

22 Tarkett (2022). Retrieved from: https://www.archiproducts.com/en/products/tarkett/carpet-tiles-desso-palatino_266044.
23 Tarkett (2022). Retrieved from: https://professionals.tarkett.com/en_EU/node/desso-carpet-tile-and-roll-solutions-innovation-functionality-and-sustainability-5527
24 Tarkett (2022). Retrieved from: https://professionals.tarkett.com/en_EU/node/tarketttape-easy-quick-and-clean-installation-of-carpet-tiles-5193
25 Tarkett (2022). Retrieved from: https://www.brandstory.nl/work/circular-carpet-lease-concept/

maintenance and substitution, that contribute to extend the lifetime of products. Finally, consumption of resources for pre-production, production and disposal is limited: products are designed to be fully recycled and regenerated for new life cycles. Carpet Tiles Leasing and the consequent extension of products lifetime allows Desso to avoid/postpone costs for of pre-production, production and distribution of new products substituting the ones disposed of. Costs for landfilling and new materials supplying is avoided as well.

5.1. Free float bike sharing – Ridemovi

Fig. 3.7 Left: bike[26]; right: interaction through the app[27]

26 RideMovi (2022). Retrieved from: https://www.ridemovi.com/press/
27 Ridemovi (2022). Retrieved from https://www.ridemovi.com

Ridemovi is a free-flow bike-sharing system - without specific racks to leave bikes. In this system, users have access to products through the app and pay per time of use. The company takes the responsibility of positioning, maintaining, repairing or disposing of the bikes. At the end of each bike life, functioning components are reused while remaining materials are separated and recycled (90% of the bike is recyclable). Bikes are designed to last as long as possible, and this is supported by full time maintenance and repair service. In particular, components are designed to be easily separated and reused or recycled.
Resources consumption for pre-production, production and distribution of new bikes are consequently reduced. The lifespan of materials is also extended through recycling.
Through the extension of bikes lifespan, Ridemovi avoids costs for new products pre-production, production, distribution and disposal. Moreover, Ridemovi saves money through recycling components, that prevent cost of supply for new materials.

5.2. Virtual office service system - YoRoom Milano

Fig. 3.8 Overview of YoRoom shared spaces and facilities[28]

28 YoRoom (2022).

YoRoom is a coworking and shared office space in the suburb of Isola in Milan. The company services are targeted to independent professionals, commercial representatives, autonomous and companies working with services. YoRoom provides a full range of services and infrastructure for a complete office. Clients only pay for the periods in which they use the service (pay-per-month). Like other virtual offices, they are spaces planned to provide efficiency and comfort, at a low cost. They are equipped with 24/7 access, smartphone key, reception service, 4 hours of meeting room per month, wifi and cable fiber connection, electricity, cleaning, relax and food area, bike storage and consultancy for favoured financing.
Environmental benefits include a decrease in consumption of products and energy savings, because of the collective use of equipment and physical space. At every stage in the consumption process there is resource optimisation. The intensive use of infrastructure, machines and tools reduces the number of manufactured products needed at any given point. At a system level there are economic benefits because YoRoom effectively has no down time compared to conventional offices. The regular use generates predictable monthly operational costs and resource demands. Important socio-economic benefits also flow with the concomitant employment generation and requirement for specialist service staff. Service providers gain customers from start-up companies reluctant to sink to many funds into infrastructure. Utilising Virtual Station clients can save 70% on administrative and routine functions compared to conventional offices. The idea of a virtual space where facilities for all kinds of office work are present is not new.

5.3. EGO, Ecologico Guardaroba Organizzato (Organized Ecologiacal Wardrobe)

EGO is an Italian company offering 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”. Once a week the user goes to the point of sale, chooses and withdraws 7 clothes, and at the same time gives back the clothes used during the previous week. EGO takes care of washing and maintaining the clothes. EGO not only manages the service but also designs the cloths and manages the manufacturing (externalised to Italian companies).

Fig. 3.9 Left: EGO service process; Right: EGO physical store[29]

29 EGO il Guardaroba (2019). Retrieved from https://www.facebook.com/EGOita/

In the traditional production and consumption model a cloth producer sells clothes to users. In this case there is a change in product ownership: cloth producer continues to own the clothes and becomes provider of a service that rents clothes; users, instead of buying clothes rent them. The main environmental benefits is given by the fact that a cloth 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 own the clothes, is economically interested in extending their life span 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 consequence to the system life optimisation, there is a resources reduction in

terms of materials and energies used to produce, transport and dispose the clothes. In addition, the washing of clothes is done using high efficiency washing machines (because, since this activity is managed by EGO, they are incentivised in reducing the cost of each single wash, and therefore in reducing the amount of energy and detergent used). On the other hand, it must be underlined that, compared to the traditional situation in which user owns the clothes and manage the washing, in the EGO system the number of washes is higher (because clothes are used after one single use).

6.1 Neighbour-to-neighbour goods sharing platform - Peerby

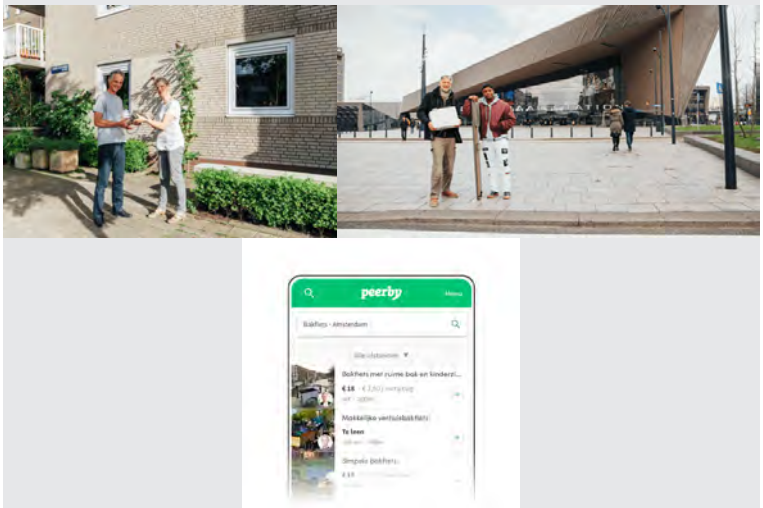


Fig. 3.10 Top: Peerby goods sharing; Bottom: Peerby app[30]

30 Peerby (2022). Retrieved from: https://www.peerby.com/

Auction and barter sites enable consumers to reuse items by buying second-hand goods, and several business-to-business exchanges are using the efficiencies of the web to recycle materials more efficiently.
Peerby supplements those efforts with a website that helps consumers share what they already own with people from the neighbourhood, which extends the life of the product among consumers. Historically, sharing has occurred between family-members, friends, and neighbours as a re-

placement for or supplement to their own purchases, and as a way to jointly purchase items that could not be individually acquired. Sharing is and has been based on a network of trusted participants and has been quite geographically limited. However, the traditional sharing structure has broken down as the population has spread out in growing cities, people have become more transient, and suburban design has limited neighbourhood interaction. As a result, the old trustworthy network is no longer tied to proximity and sharing has become more difficult. Sharing is most likely occurring on items, which are expensive and/or fill a specialised need (and, therefore, are used infrequently). For certain consumer groups sharing includes a wide range of items. Those groups include people, who lack the money or space to acquire the things they need, who live in close communities, and people, who are concerned about the environment. Internet offers free and ready-made tools and forums to enable people to identify and communicate with people in their trusted networks, and to catalogue the resources they can lend and borrow. The Peerby system allows users to make a request for borrowing an item, to which other users from the neighbourhood could answer, sharing their goods. On the other side, it is also possible to offer goods directly; in this case, potential borrowers must contact the lender to check availability of an item. Finally, the lender must give the item to the borrower, and the borrower must return it. Peerby facilitates all the first 3 steps of the process through the website. The partnership between the consumer and Peerby might define this successful and free Product-Service System, but it is the consumer, who drives the service. Peerby was designed for consumer benefits rather as a commercial enterprise.

6.2 Shopping Without Any Payment by Freitag

Freitag is a company from Switzerland that specialises in reusing truck tarpaulin to create a range of bags and other accessories. In 2019 they launched a new initiative, S.W.A.P standing for “Shopping Without Any Payment”. To take part the users must register their bag by taking a photo and uploading it to the mobile platform. Once the product

is activated for swapping, they will be able to view other swappable bags. While viewing other swappable bags they can swipe right if they like it or left if they do not. If the owner of the bag you like also likes your bag you will get a “match”. You and the other owner will decide if you want to exchange bags. Once complete, Freitag asks that the swap is confirmed with them. This process allows users who are no longer using their bags to get a theoretically new one without additional costs and without generating waste. This service offering an exchange of items prologues the lifespan of the product and increases the usage of what ordinarily would be a single owner product.

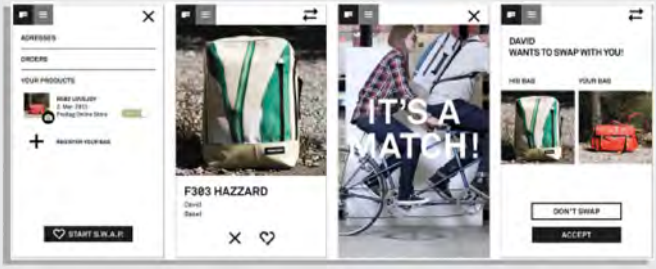


Fig. 3.11 Freitag S.W.A.P online platform[31]

31 Freitag (2019) Retrieved from https://www.fastcompany.com/90415930/freitags-new-anti-shop-lets-you-trade-backpacks-instead-of-buying-a-new-one

7. Second-hand furniture selling/renting – KAIYO

Kaiyo (formerly Furnishare) is an online marketplace for users to rent used furniture, allowing furniture to be kept in use for longer cycles.
Consumers could rent furniture with a monthly fee under different subscription plans. Kaiyo does everything for users, from pick up to delivery and everything in between, so that good furniture does not go to waste.
The source of the furniture comes from other users. When Kaiyo receives second furniture selling needs, they assess, pick up, inspect, clean, repair, store in their warehouse, photograph, and list furniture in its online marketplace.
The revenue is split between Kaiyo and the person who sells the item.
Kaiyo offers a service delivery platform for furniture reuse and second-hand selling. It is economically attractive for Kaiyo to extend the lifespan of furniture by maintenance and repair.

Transportation/distribution reduction

Transportation/distribution reduction denotes the design of system stakeholders' interactions leading to reduced sum of the transportations and packaging.
To understand in qualitative terms whether an existing system presents problems related to life optimisation, the following key questions should be asked:

- Is there any excessive transportation of goods?
- Is there any excessive transportation of semi-finished products or by-products?
- Is there any excessive transportation of people? Are the transportation means in service fully used?

Guidelines for transportation/distribution reduction

- The producer/provider uses digital channels to offer information/guidance services for purchase and care, e.g. repair and care instructions. **example 1**
- The producer/provider creates partnerships with locally-based service providers, with all-inclusive maintenance, repair, upgrade, end-of-life collection/valorisation etc.
- The producer/provider creates partnerships with locally based acknowledged suppliers of resources for the product/infrastructure pre-production, production and care, e.g. local material and energy suppliers. **examples 2**
- The developer/designer creates partnerships with product/infrastructure manufacturers for local delivery (e.g. a decentralised manufacturer network).
- Merge the product/infrastructure offer with all-inclusive services or support for their on-site assembly. **example 3**
- The producer/provider creates partnerships with retailers and other stakeholders to reduce/avoid packaging, either tertiary, secondary or primary. **example 4**
- The producer/provider creates partnerships to reduce or avoid transportation/packaging of semi-finished products, e.g. partnerships with component

suppliers and manufacturers.

- Merge the product/semi-finished product with an all-inclusive service for its transportation to optimise distribution.
- Offer products with reusable/returnable packaging
- Offer remote support and status monitoring of activities and interventions to be carried out on-site by the user, e.g. maintenance, repair, upgrade, end-of-life collection/valorisation.

examples

1. Patagonia repair & Worn Wear services

Fig. 3.12 Patagonia's Worn Wear repair station[32]

If a Patagonia product rips or tears, alternatively to the option where customers return products to Patagonia repair station (America) where a staff member will fix it, customers can follow repair tutorials available on the website to mend it themselves, with a consequent reduction in transportation.
Furthermore, customers could return broken products to Patagonia repair station where a staff member will fix it or send it to their garment repair facility, which is said to be

32 Patagonia (2022). Retrieved from https://popupcity.net/observations/patagonia-opens-store-that-sells-repaired-clothes-only/

the largest in North America conducting over 40,000 individual repairs a year. The brand also offers trade-in service and second-hand options. The trade-in service available at stores or by mail consists of the exchange of used Patagonia clothing in good condition for credit towards purchases in Patagonia retail stores, on WornWear.com or at Patagonia.com. Items that are repairable and resalable will be sold in the company's Worn Wear stores. Worn Wear is Patagonia's "hub to keep gear in play", offering a Recrafted collection made of products that Patagonia received back that are beyond repair or that cannot be recycled. Creating long-lasting products and encouraging users to return them for a reward becomes economically beneficial for Patagonia as they are making an additional profit on items that have previously been sold and generated a profit once before.

2.1 Artknit Studios

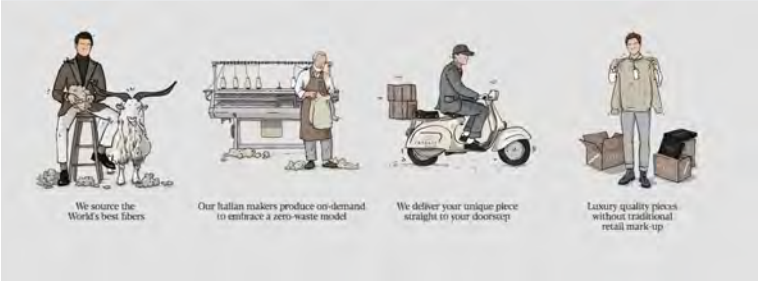


Fig. 3.13 Artknit logistic model, based on the delivery directly from manufacturers[33]

33 Artknit (2022). Retrieved from: https://www.doingitaly.com/blog/artknit-studios-zero-waste-italian-luxury-champions-regional-artisans-sustainability

Artknit Studios are paving the path for a direct to customer business model. All products are shipped directly from the makers bypassing intermediaries and intermediaries, reducing environmental and economic costs of transportation, something which is then reflected in the price customers pay. Artknit use locally sourced fibres from handpicked supplies and only work with locally based artisans to create each garment. Within their website they are aiming to operate on a transparent production system, customers can find details of the material and the manufacturer of their items.

Furthermore, Since the quality of Artknit products is so high they also produce on demand garments, to ensure they do not have excess stock which can lead to waste. To prolong the life of their garments after sale they provide information regarding how to store and care for each item. With Artknit committing to minimising resource consumption they are gaining an economical advantage since they are not purchasing unnecessary volumes of fibres, producing large volume of clothing, or needing to store clothing which cannot be sold.

2.2 Local manufacturing of global furniture design - Open Desk

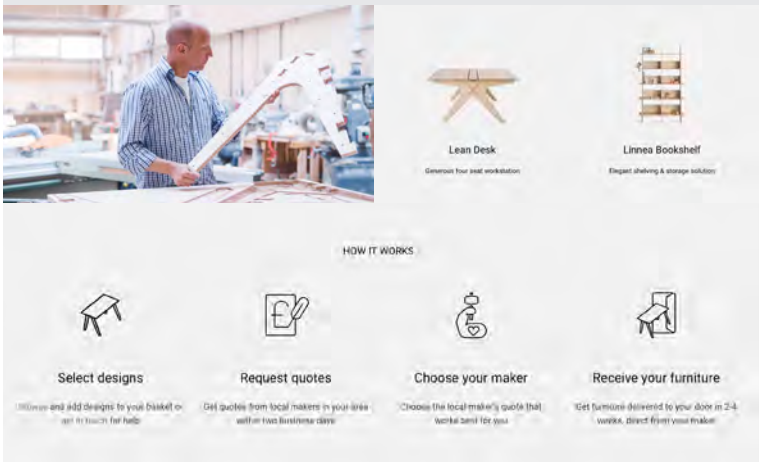


Fig. 3.14 Top-left: OpenDesk product manufacturing made by local workshops; Top-right: OpenDesk product design sample; Bottom: OpenDesk service stages[34]

34 OpenDesk (2022). Retrieved from https://www.opendesk.cc/

"Open desk" is a platform connecting customers to a library of designers, and a host of nearby craftsmen. It ensures furniture being made on-demand, locally and affordably. "Open desk" focuses firstly on workplace furniture which is the best fit for current digital fabrication technology. The procedure for customers to produce their furniture is: first, they get or produce their own furniture design. Secondary, their design is provided to a neighbourhood workshop and the furniture is manufactured with locally available materials. Finally, customers get their products at their workshop, paying for the single piece of furniture produced. In terms of environmental benefits, transportation impact is radically reduced, as compared to international shipping, thanks to

the transfer of design to local workshops.
Furthermore, Open Desk is also beneficial in terms of renewability/biocompatibility, since FSC-certified wood is the first variable in the choice of manufacturing workshops.

3. Assembly furniture at home - Ikea model

The established system model proposed by Ikea is based on the concept of selling furniture that can be easily assembled at home by the customer. Thus, all the Ikea furniture systems are designed to be as compact as possible, to be both more efficiently transported and manageable by the customer. Through the instruction manual and online support, Ikea provides additional customer service for autonomous assembly for the overall Ikea system, being based on assembly-at-home design, generate environmental benefits in terms of transportation reduction per unit of product transported.

4. Unpackaged products - Negozio Leggero

Negozio Leggero is a chain of 20 small shops In Italy, France, Switzerland, as well as online shop that sell unpackaged products, which can be collected by customers with their own reusable cans (paying just the content). The company was born in Turin in 2009 and its network is now developed all over Italy. They collaborate with the Research Institute Ecologos, to select high-quality products on a reasonable price.

Thus, Negozio Leggero, represents a new way of shopping, based on the absence of packaging, replaced by the sale of goods are sold “on tap”. Customers can use the same container over and over, reducing the amount of product packaging to be distributed.
There are more than 1500 products and range from food to body products. Negozio Leggero offers a rich variety of dry products - cereals, legumes, oilseeds, breakfast food - fruit juices, flours, eggs and fresh bread. There is also a special department of detergents, body products, make-up and perfumes all strictly “on tap”. Negozio Leggero decid-

ed to be even more sustainable and offers the option to receive the products at home. Shipments are all "plastic free" and with optimized transport with a specific delivery system, aim to reduce the impact of transport.

Fig. 3.15 Containers to get goods "on tap" in Negozio Leggero[35]

35 Negozio Leggero (2022). Retrieved from: https://www.negozioleggero.it/franchising/

Resources reduction

The reduction of resources includes 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 cancellation of environmental impact regarding what is no longer used. Using less material diminishes impact, not just 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 smaller amount of energy that must be produced and transported. Finally, on a system perspective we must consider the overall and interlinked material and energy reduction of

the whole of the products or support products needed for the satisfaction of a certain demand of needs and desires.
To understand whether an existing system presents problems in qualitative terms related to resources reduction, the following key questions should be asked:

- Is the system consuming high quantities of energy?
- Is the system consuming high quantities of natural resources? Is the system absorbing high quantities of consumables?
- Are products, packaging or support products highly material intensive?

Guidelines for resources reduction

- Complement the supply of resources/semi-finished products/consumables related to the product/infrastructure system with services for their optimal use. **example 1**
- Offer access to products/infrastructures (enabling platform) through payment based on the unit of satisfaction. **example 2**
- Offer access to products/infrastructures (enabling platform) through payment based on a fixed fee per given duration of time. **example 3**
- 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 equipment where the investment is financed through subsequent resource savings. **example 4**
- Offer collective use of products and infrastructures. **examples 5**
- Outsource and/or offer activities when higher specialisation and technological efficiency of products/infrastructures are available. **example 6**
- Create partnerships to use/integrate existing infrastructures/products.
- Outsource activities when higher scale economies are feasible.
- Complement the product/infrastructure offer with

services designed for their adaptation in the context of use aimed at resource optimisation.

- Complement product/infrastructure with services designed for their adaptation to use in variations of resource requirements.
- Offer products/semi-finished products based on availability. **example 7**
- Offer products/semi-finished products on predetermined demand aimed at avoiding unsold inventory and/or surplus production. **example 8**

examples

1. Providing chemical management services –Houghton

In the traditional relationship between chemical suppliers and their customer, the supplier makes profit by maximising the volume of sold chemicals. Chemical management services constitute a shift from such a traditional supplier relationship to a strategic alliance between the chemical supplier and its customer. Instead of purchasing chemicals the customer buys chemical management services.

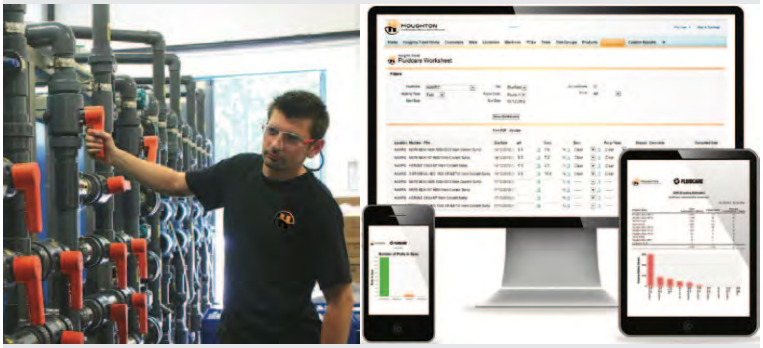


Fig. 3.16 Left: Houghton technician checks fluid levels during inspection; Right: Houghton provides a data driven approach to trach and maintain its operational focus through the use of proprietary data software[36]

The chemical provider takes a direct role with respect to managing the customer's chemicals throughout the chem-

36 Houghton Fluidcare Chemical Management Service, everything you need for optimal performance, p. 10. Available at: https://www.houghtonintl.com/sites/default/files/resources/fluidcare_brochure_short-form_-_final.pdf

ical life cycle, including the purchasing, managing and keeping track of chemicals. Thereby a shift takes place in the responsibility for the management of the customer's production processes and the quality of final products. Houghton offers fluid management services based on a fixed price business model, where Houghton takes over the responsibility for the customer's management of lubricants. The fluid management services are designed to match the customer's demand. The activities included in the management services vary from periodical visits to operators based permanently at the customer's production site. The savings gained from fluid management services are due to both hard and soft savings. Hard savings are gained by considerable reductions in the usage of fluid care products and by reduced disposal cost for discharged lubricants. Soft savings are obtained by reducing the down time on the plant and by avoiding additional labour costs. The contracts are based on fixed prices, so if it turns out that the consumption of lubricants is higher than estimated, Houghton will have to suffer from the losses. Therefore, it is crucial for Houghton to make accurate calculations of the consumption of chemicals. If there should be production losses caused by down time due to mismanagement of the production facility, it would be a discussion between Houghton and the customer who bears the responsibility. The environmental gains from fluid management services are that less lubricant is used, and therefore less fluid is produced, and the volume of fluid lubricant waste is reduced. This entails a reduction of CO2 emissions. Most of Houghton's customers have an ISO 14001 certification. By managing the customer's lubricants, Houghton helps the customer to improve their environmental performance in accordance with the ISO 14001.

2. Pay per wash warewashers- Winterhalter

Winterhalter is a commercial warewashing solutions provider. They provide pay per wash payment model, which means they are billing only per wash cycle- with all-inclusive the warewasher, tables, racks, detergent, as well as the services of transportation, installation, water treatment,

maintenance, etc. Users are neither purchasing, renting nor leasing any of the equipment or consumables. Before washing, users need to log in to the pay per wash portal and select the number of wash cycles and pay. During washing, users just need to enter the wash code on the machine display and load wash cycle credit.
Finally, this innovative interaction between Winterhalter and the client compels the company to design and provide long lasting warewasher, and resource-saving washing solutions with innovative technology to reduce water, electricity and chemical consumption, as well as reusable and recyclable warewashers.

3. Ownerless vehicle use in fixed monthly sum scheme – Riversimple

Fig. 3.17 Riversimple hydrogen-powered car: design overview from different angles[37]

37 Riversimple (2022)

A small English transport company, in 2010, started the commercialization of a hydrogen vehicle, called “Riversimple Urban Car”, which is available only with leasing agreements. Riversimple keeps the ownership of the car, and clients will pay a fixed monthly sum, which includes

the energy required to power the vehicle, insurance, and all the needed maintenance and repairs. At the end of the contract Riversimple takes back the vehicle. River simple builds human-scale, profitable operations near the markets they serve to reduce transport cost and create local jobs. The car - called Rasa- is powered by hydrogen and weighs less than half of a conventional car, while is highly aerodynamic and stable.

4. Energy-efficiency-related services and investment via realized energy savings – TAC energy[38]

The Energy Service Companies (ESCO) in the EU and in US supplied an overall package of services on a turnkey basis which comprises supply of energy resources, identification and selection of conservation measures, installation, operation and maintenance of the energy supply. They achieved an average of 30-40% savings in energy. We could say that they were selling thermal comfort instead of fuels.

TAC Energy Solutions is an ESCO, a company that provides energy-efficiency-related and other value-added services, and for which performance contracting is a core part of its energy-efficiency services business. In particular, TAC provided energy saving technologies and practices to upgrade existing equipment and reduce maintenance expenses.

In the project taken into considerations, TAC Energy solutions as an international market leader in the building automation industry was the provider, and Regionfastigheter as one of the largest building administrators in Sweden was the customer. The content of the project was energy efficiency, retrofits and refurbishments projects within three hospital areas in the Skåne region. The project involved 11 buildings (1 university hospital, 5 hospitals and 5 office buildings). Additionally, the project also involved training and capacity building of staff. The project comprised the following works:

- air handling retrofit;
- installation of heat recovery;
- rebuilding of heating and cooling systems;

38 Bio Intelligence Service S.A.S (2007) The use of renewable energy sources and measures to boost energy efficiency - significant contributions at local and regional level to combating climate change. France. Available at: https://cor.europa.eu/en/engage/studies/Documents/Use-renewable-energy-sources/Use-renewable-energy-sources-EN.pdf

- updated control systems and water saving efforts;
- new metering, energy statistics, follow up structure, and
- targeted training of administrative and managerial staff.

The principal idea behind this project was that a large part of the investment was financed via realized energy savings. TAC guaranteed a certain extent of savings. In this specific case, the investment potential of the customer (Regionfastigheter) was limited due to budget restraints and public spending restraints. Regionfastigheter was therefore not able to implement already identified saving potential in energy and operational costs by itself. It needed a provider or a partner that could carry the responsibility for detailed energy analysis, project implementation, provision and development of financial means, and finally also provide a savings guarantee. The energy service company TAC Energy Solutions could provide this. The project started in 2004/2005 and the results were positive. The early training and optimising efforts delivered more savings than expected. The business model proposed by TAC Energy Solution was eco-efficient because the economic interests of the company converge with an interest in optimising the use of resources. In fact, the large part of the investment (paid by the customer to TAC), was financed via realized energy savings. This ESCO has resulted in lower energy consumption, clearer coordination within the operational organization, upgrading of technical standards, and simple and unitary solutions.

5.1 Self-service laundry – Ondablu

Ondablu is the first and largest franchise chain of self-service laundries with more than 60 facilities throughout Italy. They offer the shared use of last generation washing machines and dryers that wash and dry all types of laundry, always respectful of the fabrics: underwear, jeans, shirts, work overalls, but also duvets, curtains etc. To ensure maximum hygiene, a medical and surgical device disinfects the machines with every wash.

The service consists of the following steps: after choosing the machine, the client inserts their items to be washed, they choose the relevant program, dosage and detergent

(provided by the shop); finally, they turn to the control board that works with either notes or coins (more practical and convenient than tokens), choose the correct washing machine and the rest is automatic. Payment per wash encourages the client to maximise the load, which consequently reduces energy, detergent and water consumption per weight of the laundry. The shared use of the washing machines also reduces production materials and waste and intensifies usage of a machine which can be used all day every day as opposed to a few times per week if there is one per household. Finally, as Millebolle is responsible for the payment of resource consumption (electricity, detergent etc.), they select the most efficient technologies/ product for both washing and drying.

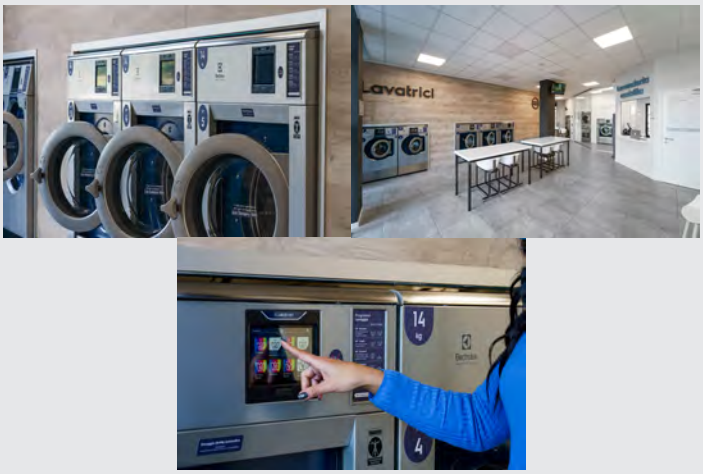


Fig. 3.18 Top left: Ondablu washing machines; Top right: the Ondablu hall; Bottom: the interface[39]

39 Ondablu, (2022).

5.2 Collective transportation with Electric minibus Gulliver – Tecnobus

Products that operate simultaneously with many consumers and can answer to greater quantity of demanded operations (i.e. collective use), can cause the reduction both in resource consumption and waste production. This can

happen due to two main reasons: economies of scale and greater professionality of hired operators. What's more, in the case of collectively used products is far easier to adopt technological levels, that enhance the consuming efficiency during its exploitation. Often than not, these systems are also more expensive and thus not always accessible for individual use. Worth mentioning are the transportation systems, that tend to be more efficient when in public or collective use. The eco-efficiency can be elevated twofold, if public transport is based on low-impact engines, as in this case the electrobus. Gulliver is electrobus in operation in European market. Its 5.32 meter length gives it a good manoeuvrability on narrow and crowded streets. Its transport capacity is for 31 passengers, the flat floor set at 330 mm gives good accessibility to children and seniors. Gulliver is supplied with continuous current engine and 85 volt battery. Fully charged battery gives it a range of 100 km and they can be recharged in 6 hours, using a simple forklift system. On downslope the engine actually accumulates energy. Gulliver has very quiet engine with 0 emission.

Fig. 3.19 Gulliver, the electric bus provided by Tecnobus[40]

40 Tecnobus, (2022). Retrieved from: https://www.tecnobus.it/index.php/it/

6. Cleaning cloth rental service – MEWA Wiesbaden

MEWA hires out swabs made of recycled cotton to engineering companies, printing plants andrepair shops to the German railway company Deutsche Bahn. MEWA urges its customers to return their dirty rags. The rags are delivered in containers to the customers, used and then thrown back into the containers to be collected by MEWA. After being

washed (by MEWA) in giant washing machines the cloths are hired out again. Each cloth completes these cycles up to 50 times. MEWA is not the cheapest option. Nevertheless, although there are cheap throwaway rags on the market, rising disposal costs for heavily soiled swabs (which count as hazardous waste) make the service a very attractive option. In fact, MEWA became the market leader in the cleaning cloth sector in Germany. Compared to other washing machine the wash process in the giant washing machines of MEWA, turn to be much more efficient. The efficiency is improved even throughout the highly specialised the staff at MEWA. Furthermore, the company has not only improved its rental service but also the material cycles involved. Solvents contained in the returned rags are used in the cleaning process, water and energy are re-used several times in cascades through the washing and drying stages, and the oil contained in sewage is recycled and used for energy production in the MEWA plant. The company's plant in Vienna has already become energetically self-sufficient through this recovery processes. After treatment in the MEWA plant, the sewage is sufficiently clean to be accepted by normal municipal sewage treatment plants without any problems.

Fig. 3.20 Top: MEWA core products (industrial cleaning cloths); Bottom-left: container for dirty swabs; Bottom-right: MEWA service stages[41]

41 MEWA (2022). Retrieved from https://www.mewa.it/

7. Organic vegetables subscription system – Odin Holland

Odin Holland provides an organically grown fruit and vegetables subscription directly to consumers. The consumer receives the produce by paying a fixed subscription fee. Once a week the consumer is sent a paper bag with assorted fruit and vegetables and accompanying recipes from an (often) organic store in the neighbourhood. One Odin bag provides fruit and vegetable needs for consumers for around four days. The selection of best available produce is made by Odin. Customers do not prespecify the mix of produce. In these conditions, i.e. selling food as the on availability of the produce, allows to reduce the surplus and thus the overall production per sale unit. Where possible Odin supplies regionally grown food which minimises transport over larger distances. For the purposes of variation, some food is imported, especially in the wintertime. All produce is supplied to Odin by growers on a fixed price contract, without going to third parties such as wholesalers.

Fig. 3.21 Odin farmers at work and service packaging[42]

42 UNEP (2002) Product-service systems and sustainability: opportunities for sustainable solutions. UNEP. Available at: https://wedocs.unep.org/xmlui/handle/20.500.11822/8123

8. Gustin

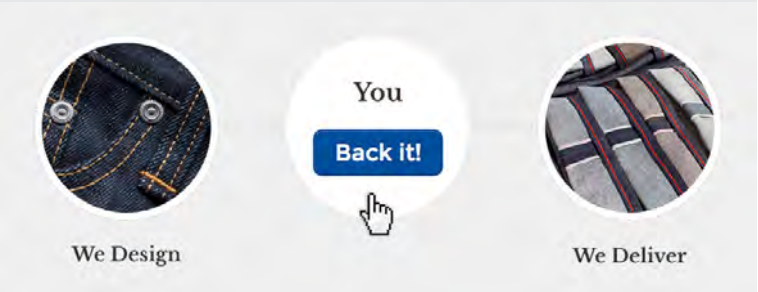


Fig. 3.22 The way Gustin do crowdsourced[43]

Gustin is focused on Crowdsourced fashion. This means that rather than encouraging customers to purchase what they have already manufactured, they design a clothing range and ask what the customers would like, tailoring their production line to the customer's needs. This is done by customers per-paying for items that they like then when the demand is reached Gustin begins production. If the demand is not met within a designated timeframe, the garment is not produced and any customers who showed interest receive a refund. They originally started as a traditional clothing producer company creating jeans that they would sell to a wholesaler for a specified price, with the wholesaler marking up the price for a profit and selling them on to the customer. Other than cutting the number of consumed resources, Gustin's new initiative of selling directly to the customer has cut out the middleman reducing clothes' transportation costs and providing a better price for the end-user.

43 Gustin, (2022). Retrieved from: https://www.weargustin.com/howitworks

Waste minimisation/valorisation

Waste minimization/valorisation entails the design for system stakeholders' interactions improving the sum of the system recycling, energy recovery and composting and reducing the sum of the waste produced.
As we introduced in previous chapters, 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 all these cases the environmental advantage is doubled (see Fig. 3.29). First, we avoid the environmental impact of disposing of materials in landfills. In the second-place resources or energy are made available for the 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, on a system perspective we have to consider the overall and interlinked avoided (or eventually added) environmental impacts of the whole of the products or support products needed for the satisfaction of a certain demand of needs and desires.

A clarification on materials' recyclability: it is common to hear that certain material is 100% recyclable. Often these statements have no meaning. In fact, in one way or in another nearly all materials are recyclable. Therefore, the reconcilability depends obviously on the specific material's

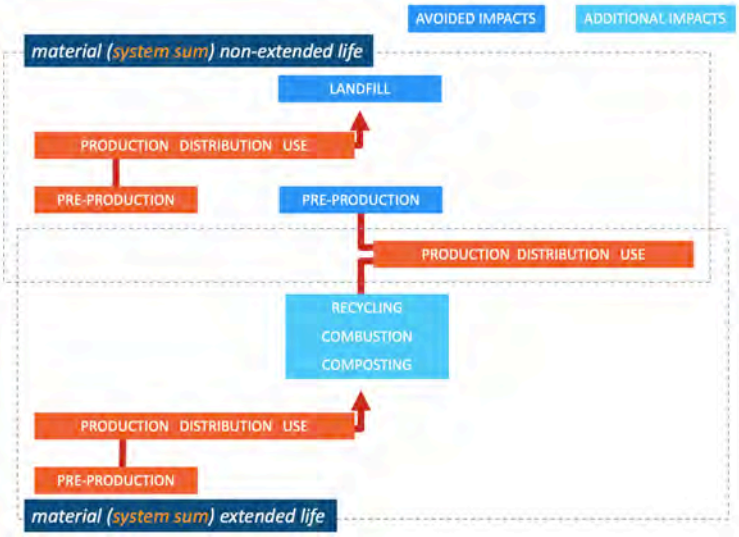


Fig. 3.23 Environmental advantages of extending the lifespan of materials of the whole of the products and support products of a certain system of satisfaction

characteristics, namely the performances recovery poten-

tial and the relative costs, e.g. metals recover their performances better than plastics after recycling.
But the recyclability depends also 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 its performances, but very hard and not convenient to be separated from others. Here they cannot be called recyclable materials.
Similarly, recyclability depends on every recycling phases, beginning from collection and transportation.
We could have a material capable of well recovering its performances, easy to be separated from the others, but much too costly to be collected and transported to the recycling sites, meaning that they are not recyclable materials.
To understand whether an existing system presents problems in qualitative terms that are related to resources reduction, the following key questions should be asked:

- Does all waste end up in landfills?
- Does the system produce high quantities of landfill waste at the end of service-life?
- Do the production, packaging and support products produce big quantities of landfill waste?

Guidelines for waste minimization/valorisation

- Complement product/infrastructure with all-inclusive take-back services aimed at recycling. **examples 1**
- Complement product/infrastructure with all-inclusive take-back services aimed at (low-impact) energy recovery.
- Complement product with all-inclusive take-back services aimed at composting.
- Create local partnerships aimed at symbiotic/cascade approach for recycling/composting of disposed products into others with lower requirements within other sectors. **examples 2**

examples

1.1 Rentable modular photocopiers – Xerox

Fig. 3.24 Top: Xerox employees during test and maintenance operations on different components; Bottom-left: printers it the warehouse waiting for disassembly and check-up operations; Bottom-right: tests on functional printer core[44]

Xerox products are designed to allow component compatibility between different models and to facilitate the whole processes of re-using or re-manufacturing. Xerox offers a package deal that includes photocopier, the maintenance and servicing, and the end-of-life collection. In fact, it has developed a systemic approach (chain management system), for re-manufacturing, re-using and recycling the components and equipment. In practice, the disposed photocopiers are disassembled in a specific factory. Components are tested and functional parts are re-manufactured or directly re-used in a new photocopier. Damaged components are destined to the material recycling (some components are recyclable at the rate of 98%). By means of this system three-quarters of the components can be re-used in new products.

44 Vezzoli, C. (2010) System Design for Sustainability: Theory, Methods and Tools for a Sustainable 'satisfaction-system' Design. Maggioli.

1.2 On Running - Cyclon

Cyclon is a recyclable running shoe developed by On Running. Runners are usually encouraged to change their trainers frequently to maintain the support of the foot and keep them running at optimal performance, this can be as often as every six months. The continual upgrading leads to millions of shoes in landfill each year. On Running has developed a subscription service to their new Cyclon shoe where users pay €25 per month for the high-performance Cyclon trainer. When the trainers begin to reach the end of their life the users are encouraged to contact On Running who will post out a new pair. They then ask that in the same box, the old trainers are returned. On Running will then recycle the returned shoes to create new Cyclon shoes. A major cost saver is that On Running do not need to resource the yarn needed for the shoes as they can reuse that from original products, saving material costs as well as not being required to pay for landfill costs.
Moreover, in coherence with this offer, the Cyclon trainer itself is a made from mono-material weave cut from a single piece of fabric. It is only available in white since this is the original material colour and therefore does not require dyes, reducing toxins. Finally, the actual material is a high-performance polyamide derived from beans. The beans are able to be grown in dry, remote places so they are not compromising the ability to crow crops. The nature of this material makes the shoes bio-degradable and fully recyclable.

2.1 Precious plastic

Precious Plastic is an open-source project which shares the blueprint of developed machines to recycle plastic waste to produce new products. The machines include a plastic shredder, extruder, injection molder and rotation molder. The processes are grinding plastic waste into small plastic chips, melting the plastic and manufacturing new products with it. There is also an online platform (davehakkens.nl/community/forums) for the community to share and exchange ideas. It is explained on the website as “See

it as an online makerspace, an open innovation think tank, a place where you can brainstorm, share suggestions, try out solutions and help innovate." So, everyone can contribute to the design of the recycling machine and designs for producing various final products. They accept donations as in-kind contribution.

In terms of environmental benefits, the project allows local production, reducing the transportation and distribution of the products. Precious plastic allows also use the plastic waste as a resource, so it makes a big impact on resource reduction. Finally, since the project use plastic waste recycling them to produce new products, it generates a great impact in terms of waste minimisation.

From a socio-ethical point of view, it favours/integrates the weaker and marginalized, enabling them to produce products out of plastic without paying for the resources and making their own DIY recycling and production machines. Precious Plastic also empower/enhance local resources, since it helps enabling local distributed production using local waste.

Fig. 3.25 Top-left: precious plastic machines (plastic shredding and fusion) at work; Top-right: extrusion and design of the new object in progress; Bottom-left: detail of a new object in production; Bottom-right: outputs of the precious plastic process[45]

45 Precious plastic, (2022). Top figures retrieved from https://preciousplastic.com/. Bottom figures retrieved from https://www.lens-international.org/

2.2 Eileen Fisher - Renew program

Eileen fisher, an American clothing company founded in 1984, runs the Renew program to extend the lifecycle of the clothes and materials by cleaning and reselling or recycling them toward new markets.
Items purchased from Eileen Fisher online or instore which are no longer fit for purpose can be returned to an Eileen Fisher clothes store, a Renew store or by shipping items directly to one of their recycling centres, regardless of their condition. For each item returned the customer will receive €5 in renew rewards. The Eileen Fisher recycling centres receive around 800 returned garments each day, totalling over 1.4 million items of clothing in the last 10 years. Each item is checked by hand to assess its quality and condition. The clothing items are then sorted into three categories (first quality, not quite perfect and damages). Items that are deemed to be lightly worn, are given a deep clean and resold at the Eileen Fisher renew shops. Items that are damaged and are beyond repair are transferred onto the “Waste No More” team who transform them into one-of-a-kind artworks, pillows and wall hangings using a custom felting method. With this method, the company avoid pre-production of primary material and avoid landfill and disposal costs even of materials that cannot be reproduced as clothing items. By utilising unusable textiles within other sectors such as artwork, they are adding another stage before disposal however, in this case, artwork is significant in that it does not wear or age like other products, in theory giving it a limitless lifespan.

Resource Conservation/biocompatibility

Conservation and biocompatibility entail the design for system stakeholders’ interactions that improves the overall amount of the system’s resources conservation/renewability.
An explanation is needed on resources renewability. Timber is renewable material, but the same type of wood can be procured from two different areas, whereas one of them is under planned and controlled exploitation and the other

one not, leading to deforestation. So, 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 the renewability depends upon 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, on a system perspective we must consider the overall and interlinked level of renewability of the whole of the materials of the whole of the products or support products needed for the satisfaction of a certain demand of needs and desires. To understand whether an existing system presents problems in qualitative terms related to conservation and bio-compatibility, the following key questions should be asked:

- Is all the energy produced from exhausting resources (e.g. fossil fuels)?
- Does the system use mainly depleting and/or non-renewable materials for products, support products, packaging, and infrastructure?

Guidelines for conservation and biocompatibility

- Engage energy suppliers offering renewable energy or renewable energy systems (eventually locally installed) for the functioning of the various phases of the product-service system. **example 1**
- Engage a material supplier to use renewable and bio-degradable materials. **example 2**
- Engage energy suppliers offering the design, installation, maintenance, repair, etc. of on-site passive energy systems for the functioning of the product-service system.
- Create partnerships that enable/increase the use of local recycled materials from disposed products of other sectors. **example 3**

examples

1. Services for decentralised energy systems – Qurrent

Qurrent does not sell energy, they teach people how to produce and manage renewable energy by their own. Qurrent is specialized in Decentralized Renewable Energy systems and develops devices, software and services that enable the creation of small Local Energy Networks.

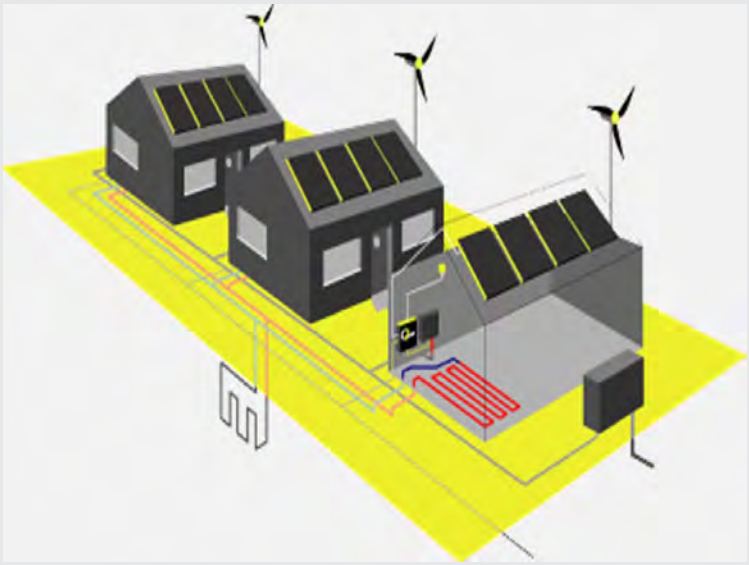


Fig. 3.26 Qurrrent minigrid energy system layout[46]

Within these networks, which are mostly privately owned, Qurrent members exchange energy to maximize the efficiency of the energy they produce. To do this, the company developed three core products: the Qbox, the Qmunity website, the Qserver; together they constitute the Local Energy Network. Qbox i is a Local Energy Network (LEN) Interface. It is at the heart of a building's infrastructure, and it communicates with the surrounding buildings. It measures all electricity production and consumption and makes it possible to share capacities with your neighbourhood. In that process, it considers the energy rates, however varying they may be, government subsidies, user production and consumption profiles and personal preferences you

46 Vezzoli, C., Kohtala, C. and Srinivasan, A. (eds) (2014) Product-service system design for sustainability. Sheffield: Greenleaf Publishing.

might have. Qbox can autonomously switch on the home appliances when it is most efficient. The Qmunity website is the place where Qurrent members go to analyze their energy consumption and production. It is also the place where they can set the switches of the Qbox. and of course, it's a true community, so it's the place to exchange information and knowledge with Qurrent or other members. The Qserver is the core of the Qurrent system for decentralized energy networks. Its main role is to store all data being measured by all member Qboxes and then to present it through the Qmunity website. While the name is singular, the Qserver will consist of many clustered servers spread out over different locations to ensure the highest levels of data security and speed.

2. Quality organic food – slow food in Poland

Fig. 3.27 From left to right: sample of Visana partner producer; Sample of producer shops; Visana brand and product[47]

Working with a group of producers, who lacked their own wide-scale distribution network, Visana produced its own brand Soplicowo i okolice, a logistics and distribution network. Visana trades in traditionally farmed, organic produce, and promotes the idea of slow food. It cooperates with local producers, offering better sales opportunities for their products in exchange for production under the Soplicowo i okolice label. It also provides city consumers with an access to high-quality products from a trustworthy source. Now there are, working under the common Soplicowo i okolice brand, 13 producers and around 40 distributors in Warsaw alone, with all the participants profiting from the co-operative venture. Producers and distributors split the risks and profits evenly. The company is employing more staff, the production firms are expanding, by investing in a machine park,

47 Meroni, A., 2007. Creative communities. People inventing sustainable ways of living. Edizioni POLI.design, Milano. https://www.strategicdesignscenarios.net/wp-content/uploads/2012/01/EMUDE_Creative-communities.pdf

and as confidence grows, new ideas emerge all the time. Traditional food is offered as a new lifestyle, also enhancing consumer awareness and concern for the source and quality of products. Visana's products are made from natural ingredients and grown in environmentally friendly conditions. The soil is fertilised with natural composts, and the fruit and vegetables contain no pesticides. This encourages traditional farming methods with fertilisers that do less harm to the environment.

3. RIFÒ LAB

Fig. 3.28 Organization of retrieved materials according to alike colours. In small: a sample product made with discarded textiles from other products[48]

48 RIFÒ LAB (2022). Retrieved from: https://rifo-lab.com/en

Rifò Lab is an Italian company based in Tuscany that produces and sells clothes using fibres regenerated from the clothing manufacturing district of Prato.
Indeed, the production is based on different methods that allow to regenerate discards into new valuable fibres mechanically. Cashmere can rely on regenerated fibres for its 95%, Jeans up to 85%.
In this way, Rifò's production is minimally based on virgin resources, since it works through the collaboration with suppliers to use materials that are disposed from other sectors.

Toxicity reduction

Reduction of toxic emissions entails the design for system stakeholders' interactions that reduce/avoid the gross total of toxicity and harmfulness among the resources utilised or emitted by the system.
Regarding to this is important to remember that a properly effective approach must always refer to the entire life cycle and to every concurring process of all the products and the support products of a particular system of satisfaction. Meaning that various technologies for transforming and treating materials (some of them might entail toxic or noxious emissions, others equally effective might not) must be considered along with distribution systems that cause the least harm to the environment, products designed to use energy and consumable resources less invasively. Finally, we must orientate our choice of materials (and additives) towards minimizing the emissions that occur during disposal.
To illustrate materials' environmental impact, we must understand that except toxic materials, (like asbestos, which should 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 like a polymeric matrix filled with fibres. Though it is used to manufacture disposable dishes, it is a poor material in terms of environmental impact, since it causes many problems during disposal, and uses a high concentration of resources in production.
On the other side, the same composite material could have with a low environmental impact if used to produce some parts of a product, which would be heavily transported, so forth having the greater impact in the usage phase due to fuel consumption. While this material is probably lighter than others, it will reduce the whole transportation consumption by reducing the overall weight. Therefore, it might be also good or at least a better material in environ-

mental terms. For this reason alone, it would be misleading to propose scaled environmental impact ranking of different materials.
Finally, on a system perspective, we must consider the overall and interlinked toxicity of all the materials and processes of the products or ancillary products needed for the satisfaction of a certain demand of needs and desires.
To understand whether an existing system presents problems in qualitative terms related to toxic and harmful resources, the following key questions should be asked:

- Are the processed resources toxic or potentially toxic for the workers?
- Are the processed resources toxic or potentially toxic in during distribution?
- Are the processed resources toxic or potentially toxic for the user?
- Are the products, support products, packaging or infrastructure toxic or potentially toxic during after service time treatments?

Guidelines for toxic reduction

- Create partnerships with other producers to reuse or recycle toxic/harmful substances.
- Complement the product/infrastructure/semi-finished products with services that minimise/treat toxic or harmful emissions they cause in pre-production, production and use stages. **examples 1**
- Complement toxic or harmful substances/semi-finished products with all-inclusive end-of-life treatments. **example 2**
- Offer toxic management services to stakeholders of the product value chain, through payment based on the unit of satisfaction. **example 3**

examples

1.1 Lubricants as a service – S.A.T.E Klüber Lubrication

Klüber Lubrication has moved from selling to commercial customer just lubricants to a service providing added value to product use. Using a service called S.A.T.E. it analyses the effectiveness of aerosol treatment plants and sewage treatment. For this purpose, Klüber Lubrication 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 which Klüber Lubrication offers clients, leads to plant improvement in term of efficiency, guarantees functionality and durability, and enhances environmental protection.

Fig. 3.29 Kluber Lubrication monitoring consultancy[49]

49 Klüber Lubrication (2022)

1.2 Zyosh

As clothes are subjected to repetitive washing, they start to release a larger quantity of microplastics. Zyosh has developed innovative technology in the form of a clothing label that is attached to clothes like a regular sewn-in tag to inform the user of the "optimal time to recycle" to prevent the weakening of the textile and minimizing the emissions of microplastics. Zyosh creates the tag for companies tailored specifically to the composition of their clothing. They take

this information, encrypt it, and transform it into a QR code. When it is sewn into a garment the QR code is invisible. As the user washes their clothing the code appears. When scanned QR code provides information on where to recycle the item, whether the retailer offers a take-back service, or whether to contact Zyosh to arrange a collection. Finally, the label explains recycling best practices that can be used across all clothing items, not just those with the Zyosh label, such as, removing buttons and labels at home.
A key point here is that Zysoh does not directly reduce toxins within the clothing system. They do, however, provide vital information (in partnership with clothing manufacturers) to the customer who can then make an active decision as to whether to recycle the garment or not.

2. Chemical distribution – SAFECHEM Europe GmbH

Fig. 3.30 Double skin containers for the Safe-tainer system[50]

The SAFE-TAINER™ System is a closed-loop solvent management system that combines the supply of solvents with the collection of the used solvent . It consists of two different exclusively designed double-skinned containers – one for the supply of fresh solvent, and the other for the

50 SafeChem Europe GmbH (2020). Retrieved from http://www.efkimya.com/pdf/katalog_16_serisi_1.pdf

collection of used solvent. The steel outer casing protects the drum inside and prevents spills during transport, handling, storage and use. The drum is further fitted with special leak-free couplings to prevent spills, leaks or vapour emissions during solvent transfer.
The container for fresh solvent is designated for the transport of virgin solvent, ensuring highest product quality. And the container for used solvent is 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 solvent.
SAFECHEM delivers virgin bulk solvent to filling stations, normally located at the distributor's site, where it is stored in tanks and filled into the SAFE-TAINER™ System. The distributor delivers the container for fresh solvent together with the container for used solvent to their customer. The customer connects the container (for fresh solvent) to his cleaning equipment (closed vapour degreaser or dry-cleaning machine) using special accessories of the SAFE-TAINER™ System. The used solvent is pumped into the designated container for used solvent, which is collected by the distributor when full. The waste is then extracted from the container, 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 can be returned to the market .

By enabling used solvent to be recycled and re-used in the market, SAFECHEM helps close the resource loop by managing the delivery, collection and recycling of the solvents using the SAFE-TAINER™ System . SAFECHEM further supplements the application of the SAFE-TAINER™ System with educational solvent trainings for its customers, focusing on the correct handling of the SAFE-TAINER™ System as well as optimisation of the solvent cleaning process. It is the management of the SAFE-TAINER™ System through SAFECHEM that is key to the Product-Service system. The SAFE-TAINER™ System has been introduced to help meet customers' needs for solvent cleaning while enabling virtually emission-free solvent transfer.
The SAFE-TAINER™ System has been specially designed

by SAFECHEM to allow companies using chlorinated solvents - trichloroethylene, perchloroethylene and methylene chloride – as well as modified alcohol solvents in metal and surface cleaning lines to handle the solvents safely while meeting both the performance and environmental demands of their operations. With the use of this system in combination with modern closed cleaning machines, solvent users can improve their solvent cleaning operations by enabling safer and emission-free handling of solvents and effective waste management. This product-service system not only allows SAFECHEM to promote and educate the safe handling, usage, transport and storage of chlorinated and modified alcohol solvents. It also enables a safer workplace and environmental protection while allowing end users to benefit from high quality cleaning with solvents.

3. Providing chemical management services – PPG Industries

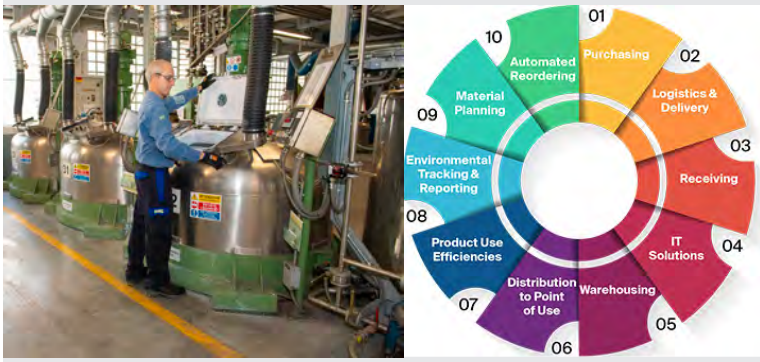


Fig. 3.31 Left: PPG employee operating on plant systems; Right: PPG chemical management service stage[51]

51 PPG (2020)

Founded in 1883, PPG is a global supplier of paints, coatings, optical products, and specialty materials (e.g. chemicals, glass and fibre glass). PPG helps customers in industrial, transportation, consumer products, and construction markets and aftermarkets. PPG offers a turnkey outsourcing program for chemical and fluid management, process management and logistics - custom designed to include sourcing, purchasing, and vendor management.
In particular, PPG cooperates with General Motors (GM)/

Opel on a process and chemical management programme at GM's plant in Gliwice, Poland. All initial investments at the plant were made by GM. PPG is paid by cost per unit and the consumption of chemicals is calculated based on expected usage. As a part of the contract PPG is obliged to continuous reduction of cost per unit. Only GM gains from the savings and there are thereby no gain-sharing mechanisms in the contract. The environmental improvements include reduction in chloride concentration in the wastewater and reduction in the amount of wastewater sludge. The programme has led to monthly savings in the magnitude of € 10,000. As a part of the contract PPG is obliged to continuous reduction of cost per unit, and so it is economically motivated in reducing chemical usage, reducing water and energy usage and substituting chemicals with less toxic chemicals. The plant complies with the local environmental standards, and PPG assist GM in being capable to meet future environmental regulation.

3.2 Strategies, guidelines and examples to design socially sustainable PSS

It is rather obvious, that not all system innovations are socio-ethically sustainable. So, it is particularly important to look at cases studies and develop strategies and guidelines as well as methods/tools to manage and orient the design process towards socio-ethical solutions. But so far very few tools and methods have been developed to orientate such strategic design process.
Some of those methods and tools are presented in chapter 7, but now we should focus on the design strategies and guidelines for social equity and cohesion.

There are six principal areas of action/strategies[52] when it comes to designing for socio-ethical sustainability. These are:

- Improving employment and working conditions;
- Improving equity and justice in relation to stakeholders;
- Enabling responsible/sustainable consumption;
- Favouring/integrating low income, weaker and marginalised;

52 Within the MEPSS EU funded 5th FP and more recently the LeNS EU funded multiregional capacity building projects.

- Empowering/enhancing local resources;
- Improving social cohesion.

There are interrelations between social equity and cohesion (and related guidelines), meaning that for a given satisfaction system, some strategies (and related guidelines) have higher relevance than others. Therefore, in any decision-making process (designing) it is important to identify the (socio-ethical) design priorities; namely which strategies are the most relevant per system type, i.e. the most promising stakeholder interaction types (strategies and related guidelines).[53]

53 See paragraph 4.2.2: Sustainability Design- Orienting toolkit (SDO).

In the remainder of this section, we will go through each of these in detail and provide some guidelines on how these may be addressed in the design process. Examples and case studies[54] will also be provided for each criterion.

54 A rich source for those cases has been the outcomes of the European Research EMUDE, Emerging User Demands for Sustainable Solutions provided much valuable information".

Improving employment and working conditions

When speaking about employment/working conditions we refer to design that promotes and enhances employment/working conditions within the enterprise.

The role of the designer could be marginal in this case as employment/working conditions are often determined by companies and are intrinsic to organizations, their goals and requirements. Nevertheless, the designer could at least be active in promoting fair employment and improving working conditions through various means of communication.

To understand whether an existing system presents problems related to employment/working conditions in qualitative terms, the following key questions should be asked/answered:

- Are there any problems with forced or child work?
- Are there any problems with health and safety?
- Are there any problems of discrimination in the workplace?
- Are there any problems with work overload and/or in-

adequate wages?

- Are there any problems with freedom of association and right to collective negotiation?

Guidelines for improving employment and working conditions

- Offer the access rather than mere product/equipment ownership to open new market opportunities for local entrepreneurs in low/middle-income context. **example 1**
- Improve and maintain good working conditions. **examples 2**
  - Avoid/eliminate forced and underage work.
  - Avoid/eliminate all forms of discrimination in the workplace.
  - Provide freedom of association and right to collective negotiation.
  - Improve the health and safety of workers.
  - Define and adopt tools, standards and certification of social responsibility for the enterprises/organisations.
- Promote adequate working hours and fair wages.
  - Guarantee that wages are fair and adequate to the number of working hours (in the whole value chain).
  - Guarantee adequate number of working hours.
- Promote and enhance satisfaction, motivation and participation of the employees.
  - Offer a workplace that is adequate to employees' capacities and needs.
  - Guarantee continuous development and training for workers.
  - Avoid alienation and keep employees engaged and ambitious.
  - Involve workers/employers in decision making processes.
  - Create a working climate that takes into consideration innovations suggested by workers.
  - Collaborate with colleges to offer good working conditions in the whole value chain.

examples

1. Lowe's, 3D printing and scanning service

Lowe's Innovation Labs developed a project in partnership with Authentise, providing secure distribution tools and services for 3D printing and scanning as a "consumer workbench". The innovative software and service allow 3D files to directly be streamed to 3D printers without downloading the file, which prevents the illegal use/distribution of the files and simplifies the process for users. Due to the secure files' distribution, it encourages more designers to distribute and sell their designs through the internet. The simpleness also makes 3D printing accessible for more users without any knowledge about 3D printing.
Customers can purchase a 3D file, customize and change the design in the software provided in Lowe's store and get them printed with the material they chose such as plastic, steel or gold. In this case, they pay for the final product according to their customization. They can also use the printers and scanner in the store for scanning their own objects and printing their own files paying for use and material.
This effort bridged the gap between consumers and 3D printing by giving consumers access to the tools. But more so because it charts a new path, a model for how other retailers and businesses, large and small, can offer 3D services.

2.1 Transparency, accountability, reporting and sustainable development - Global reporting initiative (GRI)

Fig. 3.32 GRI sets a new global benchmark for sustainability reporting[55]

Global Reporting Initiative (GRI) is an independent inter-

55 Global Reporting Initiative (2022). Retrieved from: https://www.globalreporting.org/standards/standards-development/universal-standards/

national organization headquartered in Amsterdam with regional offices around the world that helps businesses, governments and other organizations understand and communicate their sustainability impacts. The GRI is a meeting place to converge and accelerate these issues of transparency, accountability, reporting and sustainable development. The GRI's vision is that reporting on economic, environmental, and social performance by all organizations would be as routine and comparable as financial reporting. The GRI network accomplishes this vision by developing, continuously improving and building capacity around the Sustainability Reporting Framework, the core of which are the Sustainability Reporting Guidelines. To ensure the highest degree of technical quality, credibility, and relevance, the GRI Reporting Framework is developed and incessantly elaborated through intensive multi-stakeholder engagement, that involves reporting organizations and information seekers, who together develop and review content for the Reporting Framework. Today nearly 1000 organizations in over 60 countries have declared their use of the GRI Reporting Framework. The GRI is a collaborating centre of the United Nations Environment Programme that drives the organizations to adopt a sustainability report thus bringing benefits to workers (safeguards of health, safety and rights), to the organization (brand reputation), and to the consumer (transparency of the offer).

2.2 Sustainability Accountability, SA8000 certification

SA8000 is an international standard for improving working conditions. Based on the principles of thirteen international human rights conventions, it is a tool that helps applying these norms to practical work-life situations. Sufficiently specific to be used by audit companies and contractors alike in multiple industries and countries, SA8000 represents a major breakthrough: it was the first auditable social standard and creates a process that is truly independent (it is neither a government project, nor dominated by any single interest group). To certify conformance with SA8000, every facility seeking certification must be audited. Thus, auditors will visit factories and assess corporate practices on a wide

range of issues and evaluate the state of company's management systems, necessary to ensure ongoing acceptable practices. Once an organization has implemented all necessary improvements, it can earn a certificate attesting to its compliance with SA8000. This certification provides a public report of good practice to consumers, buyers, and other companies and is intended to be a significant milestone in improving workplace conditions.

Fig. 3.33 Anker Research Institute's Living Wage and Income Corporate Sponsors program[56]

56 Marcel Crozet/ ILO (2022). Retrieved from: https://www.flickr.com/photos/ilopictures/49846155588/in/album-72157714133161636/

Benefits for Workers, Trade Unions and NGOs are:

- Enhanced opportunities for organising trade unions and collective bargains.
- 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:
- 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.

Improving equity and justice in relation to stakeholders

Equity and justice in relation to stakeholders means that the design promotes and enhances fair and just relations (outside the enterprise): within and among partnerships, upstream and down-stream, as well as in the community where the offer takes place. In qualitative terms the following key questions could be asked to understand whether an existing system presents problems related to enhancing equal and just relations between stakeholders:
- Are the stakeholders criticising the supply system?
- Is the client/final user criticising the supply system?
- Are there any unjust relations between the partnerships?
- Are there any unjust relations with suppliers, subcontractors and sub-suppliers?

Guidelines for improving equity and justice in relation to stakeholders

- Promote and enhance fair and just partnerships.
  - Support and involve partners in low and middle-income contexts.
  - Support and involve partners active in social activities.
  - Involve organisations engaged in the diffusion of social equity standards.
  - Promote and facilitate knowledge exchange between partners and stakeholders.
  - Extend the definition and/or the adoption of standards and tools for socio-ethical responsibility to stakeholders.
  - Offer stakeholders adequate information flow.

- Increase stakeholders' productive capacity.

- Promote and enhance equal and just relations with suppliers, sub-contractors and sub-suppliers. **examples 1**
  - Join and support fair-trade activities /development aid activities.
  - Promote cooperation and projects in low and middle-income contexts.
  - Consider stakeholders' expectations and address suppliers/subcontractors needs and interests.
  - Involve suppliers, subcontractors and sub-suppliers in the design (and decision making) processes.
  - Require other companies that take part in the value chain to safeguard working conditions as well as health and safety.
  - Promote/require the adoption of social certification systems by suppliers, subcontractors and sub-suppliers.
  - Define and/or adopt standards and tools to certify companies' social and ethical practices.
- Promote and enhance equal and just relations with clients and/or end-users.
  - Offer products and services which guarantee the health and safety of clients/ final users.
  - Promote products and services that improve health and safety and reduce discrimination and marginalisation.
- Promote and enhance equal and just relations affecting the community where the offer takes place. **example 2**
  - 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.

examples

1.1 Fairtrade International and FAIRTRADE Mark

Fig. 3.34 Fairtrade mark and product bearing the mark[57]

Fairtrade International, established in 1997, is a non-profit umbrella organisation that unites 22 member organisations which include various producer networks in Africa and the Middle East, Asia-Pacific, and Latin America and the Caribbean, as well as national Fairtrade organisations. Fairtrade International offers the following services:

1. Development of Fairtrade Standards that benefit small farmers and workers, promote sustainable production, guarantee a fair price and an extra Fairtrade Premium. Fairtrade Standards go further than Codes of Conduct and other social labels: beside minimum requirements that producers and traders must meet, Fairtrade International expects them, through progress requirements, to continuously improve working conditions, to increase the environmental sustainability of their activities and to invest in organisational development for workers and small farmers.
2. Producer Business Support. It facilitates producers' compliance with the Fairtrade Standards and provides them with information to strengthen their businesses and seize new market opportunities.
3. The FAIRTRADE Mark is an independent consumer label which appears on products as an independent guarantee that disadvantaged producers in the developing world are getting a better deal. Fairtrade certification empowers farmers and farm workers to lift themselves out of poverty by investing in their farms and communities, protecting the

57 Fairtrade (2022). Retrieved from: https://www.fairtrade.net/about/fair-trade-marks

environment, and developing the business skills necessary to compete in the global marketplace. In order to display the FAIRTRADE Mark a product must meet international Fairtrade standards, set by the international certification body of Fairtrade International. Independent certifiers audit producers, traders and companies and check whether or not they are compliant with economic, social and environmental standards which include for example that producers receive the Fairtrade Minimum Price (minimum price that covers the cost of sustainable production) and Premium (extra money that can be invested in social and economic development projects). The Fairtrade principles include:

3.1 Fair price: Democratically organised farmer groups receive a guaranteed minimum floor price and an additional premium for certified organic products. Farmer organisations are also eligible for pre-harvest credit.

3.2 Fair labour conditions: Workers on Fairtrade farms enjoy freedom of association, safe working conditions, and adequate living wages. Forced child labour is strictly prohibited.

3.3 Direct trade: With Fairtrade, importers purchase directly from Fairtrade producer groups, eliminating unnecessary intermediaries and empowering farmers to develop the business capacity necessary to compete in the global marketplace.

3.4 Democratic and transparent organizations: Fairtrade farmers and farm workers decide democratically how to invest Fairtrade revenues.

3.5 Community development: Fairtrade farmers and farm workers invest Fairtrade premiums in social and business development projects like scholarship programs, quality improvement trainings, and organic certification.

3.6 Environmental sustainability: Harmful agrochemicals and GMOs are strictly prohibited in favour of environmentally sustainable farming methods that protect farmers' health and preserve valuable ecosystems for future generations.

1.2 World Fair Trade Organization (WFTO) and WFTO Label

WFTO's mission is to enable producers to improve their livelihoods and communities through Fair Trade. WFTO aims to be a global network and advocate for Fair Trade, ensuring producers' voices are heard. Over 300 Fair Trade enterprises in 76 countries form the basis of the network and membership is growing steadily. More than 70% of the members are in developing countries in Asia, the Middle East, Africa and South America, with the rest coming from North America & the Pacific Rim and Europe. WFTO's primary mission is to verify Fair Trade Enterprises against the 10 Principles of Fair Trade. It assesses the entirety of a business (i.e. from the enterprise's structure and business model to its operations and supply chains) and not just a specific product, ingredient or supply chain (i.e. as in the case of the FAIRTRADE Mark or other commodity certifiers). WFTO's work is centred around three areas:

Market Development (developing the market for Fair Trade): WFTO encourages the development of the Fair Trade market, to help increase the opportunities for marginalised, small-scale producers.

Fair Trade Monitoring (Building trust in Fair Trade): to help increase public trust in Fair Trade Organizations, WFTO uses a structured Fair-Trade monitoring and verification scheme called the WFTO Guarantee System. This five-step monitoring, and verification scheme ensures that WFTO members are trustworthy in their commitment to Fair Trade. It consists of the following steps: membership admission procedure, Self-Assessment Report, Monitoring Audit, Peer Visit, and the Fair-Trade Accountability Watch. WFTO members, once fully verified, are entitled to use the WFTO Guaranteed Fair Trade label free of charge on all their products.

Advocacy: Speaking out for Fair Trade and issues related to the overuse of natural resources, women's empowerment, refugee livelihoods, human rights, inequality and sustainable farming to mention but a few.

1.3 Altromercato consortium, for fair trade

The Altromercato consortium is the main Italian fair trade organisation. Made up of more than 140 associations and cooperatives that manage more than 200 shops (Empori, Botteghe, Bottheghe di distretto and Outlets) in Italy, where fair trade products are offered, and information and education are given on North-South unjust issues. Altromercato products could be found as well in supermarkets, local shops and in public food services. Altromercato has been created in Bolzano in 1988 by diverse groups of persons and associations in reaction to the unjust commercial relationships between North and South. Fair trade is based on a proper price paid to the producer and on an equal relation between small groups of democratically organised manufacturers and Altromercato purchase central. The project contributes towards respecting manufacturer rights and facilitating trade with emerging countries. Furthermore, the association is additionally self-financed by second-hand auctions and by providing other services. Finally, Altromercato cooperates only with manufacturers/suppliers of organic farming. Altromercato is one of the organisations that is registered with a WFTO mark.

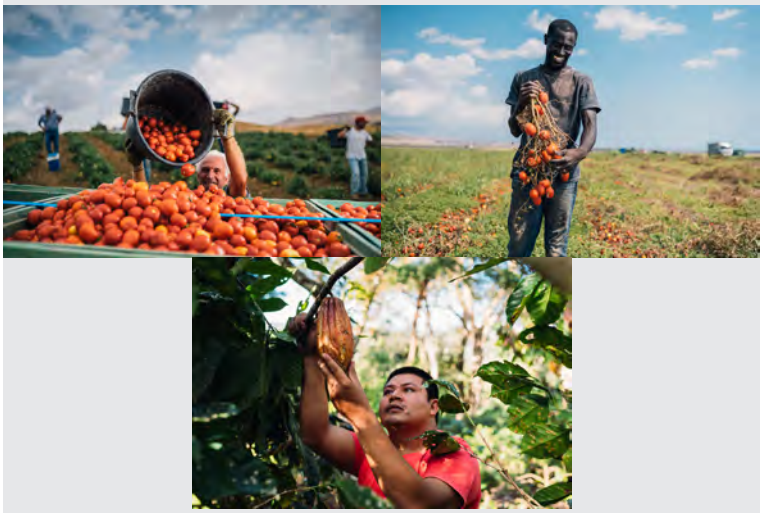


Fig. 3.35 Altromercato's producers[58]

58 Altromercato (2022). Retrieved from: https://www.altromercato.it/el-ceibo/

2. People get cheap bicycles - Bicycle Flea Market

The Bicycle Flea Market repairs and resells donated bicycles. Funded by Uusi Tuuli in the city of Turku (Finland) it is run by volunteers, mostly unemployed, who are willing to work for the common good, and want to maintain their repair skills. The flea market began by selling everything but was not profitable. Volunteers work two to four hours every weekday. Sometimes they are joined by people sent by the Unemployment Office, who are taught how to use tools and repair bikes and leave three months later with a new skill. Repaired bikes are displayed next to the entrance. New owners are given a one-month warranty. It helps to develop or maintain manual skills and enable workers to feel a valuable part of society. Those who choose to work here are willing to learn and teach others. They also do not have to pay any tax. It promotes employment, ecological transport, reduces waste and turns abandoned bikes into valuable products, resulting in a benefit for the community of Turku. Customers benefit from a cheap bike with a warranty. It helps Turku students save money on public transport, and commute in environmentally friendly way.

Fig. 3.36 The Bicycle Flea Market project[59]

59 Meroni A., (edit by), Creative communities. People Inventing suatinable ways of living, Edizioni Polidesign, Milano, 2007. https://www.strategicdesignscenarios.net/wp-content/uploads/2012/01/EMUDE_Creative-communities.pdf

Enabling responsible/sustainable consumption

Enabling responsible and sustainable consumption entails a design that promotes and enhances responsible and sustainable behaviour and choices made by clients and/or final users. To understand in qualitative terms whether an existing system presents any problems related to (ir)responsible and (un)sustainable consumption, the following key questions could be asked:

- Is the client/final user able to acknowledge clearly and easily the social (un)sustainability along the whole value production chain?
- Is the client/final user able to understand the responsible/sustainable behaviour promoted by the supply system?

Guidelines for enabling and promoting responsible and sustainable consumption

- Enhance the social sustainability of all stakeholders, e.g. adopt standards to increase the transparency of supply chains, underlining its social sustainability.
- Complement the product-service system offer with information and/or learning experiences that educate the client/end-user on sustainable behaviour and choices. **example 1**
- Offer product-service systems that enable clients/end-user to participate responsibly/sustainably. **examples 2**
- Involve the client/end-user in the production/ implementation /customisation of their product-service system to encourage more responsible/sustainable consumption and behaviour. **example 3**
- Involve the client/end-user in the design/decision-making process of their own product-service system to encourage responsible/sustainable consumption and behaviour. **example 4**

examples

1. Tolhurst Stockfree Organic Farm in England, a farm with an emphasis on education and conservation

Tolhurst Organic is a Community Interest Company located outside the village of Whitchurch-on-Thames in south Oxfordshire, England. The farm has held the organic symbol for over 40 years, making it one of the longest running organic vegetable farms in England. The farm also creates a model for Stockfree (animal free) organic farming and it was the first farm in the world to attain the “Stockfree Organic” symbol in 2004, meaning that it has had no grazing animals and no animal inputs to any part of the farm. Tolhurst Organic offers information and a range of learning experiences to educate students, clients and consumers about the social and environmental sustainability benefits of organic animal free farming. Stockfree organic systems use considerably less land than livestock dependent systems, have a much lower carbon footprint and lower energy requirements. Growing food without using animals is also safer. By removing animal inputs form farming, fewer pathways for pathogens are present - which are an ever increasing concern with regard to diseases such as e.coli - and exposures to high levels of antibiotics or other chemical residues from manure are also avoided.
Tolhurst Organic aims to promote sustainable production and consumption by showing how to produce high quality, locally available and organically grown food without the use of slaughterhouse by-products or animal manures. Besides providing various veg box schemes to customers, and selling produce at stalls and markets, the farm also has a range of on-farm opportunities ranging from school visits and farm walks to volunteer opportunities and internship placements. Activities range from: nature walks in the garden, beetle watching, bird watching, berry collection, weeding, harvesting, compost mixing and sketching. The farm also offers three-months traineeships to local and international students and future growers, from April to July and from August to October. In addition, specialist organic

advice to farmers, growers and students is also available and delivered in several forms e.g. based at their own farm, at other farms or in the office.

2.1 +BC, service promoting the culture of in-city cycling

+BC (standing for the vernacular Italian for more bicycles) is an Italian association - supported by the Municipality of San Donato Milanese - of bicycle experts, inventors and enthusiasts who encourage the culture of cycling in the city by supplying services like hiring second-hand bicycles, technical help, maintenance and creativity workshops, parking facilities and bicycle security.
It also organises cultural activities and provides consultancy services on sustainable transport. +BCs services are open to everybody, there is no system of membership. The +BC workshops are managed by the users, under the supervision of an expert mechanic. The solution empowers people by helping them to start using bicycles instead of using cars and teaching them how to repair their own bikes. The service enables users to maintain their own bicycles for a low price. Cycling contributes to a better environment and healthier lifestyle. Finally, they foster integrating bicycle and subway transportation, highly effective in helping to solve traffic and pollution problems in large cities.

Fig. 3.37 Street bike workshops[60]

60 +BC (2022). Retrieved from: http://www.piubici.org/attivita/ciclofficine-di-strada/

2.2 Jardin Nomade, Association Quartier Saint Bernard in Paris

Nomad Garden - supported by Association Quartier Saint Bernard (AQSB), a district association in Paris - is a shared garden of 280 m2. The inhabitants take care of this collec-

tive space, while at the same time an environmental education programme for children, promoted by local schools, also takes place here. Various events are also organised: from community celebrations to various workshops and activities that are open to everyone: gardeners, members of the association, neighbourhood residents and passers-bys etc. and access is free of charge. The Nomad Garden is part of the “Main Verte” network created and run by the city of Paris, a project designed to respect environment and biodiversity while encouraging local participation and civic responsibility, especially in young people. The Nomad Garden promotes interactions between different generations and environmental awareness; it involves schools and associations and overall creates a “healthier” environment.

3. Inhabitants improve living condition - Neighbourhood Shares, The International Institute for the Urban Environment (IIUE)

Fig. 3.38 Neighbourhood shares instruments and tools[61]

Residents have taken over responsibility from the local authority for certain maintenance tasks for their neighbourhood, such as tending gardens and tidying streets. The residents’ association decides, with the local authority, what work needs doing, then organises it amongst local residents. Although the local authority pays for the work, the responsibility is devolved to the residents’ association. The local authority and environmental organisations give the residents practical advice, and environmental awareness. The residents learn how to take care of their own environment by themselves and become motivated to complete maintenance tasks. By showing residents how to value, maintain and take care of their own environment, The Hague could become a good example for other cities. By tending gardens and tidying streets, the project has made this corner of The Hague a healthier place to live.

61 Meroni, A., 2007. Creative communities. People inventing sustainable ways of living. Edizioni POLI.design, Milano. https://www.strategicdesignscenarios.net/downloads/Publications/Creative%20Communities.pdf

The system saves the community money. The local authority not only transferred the responsibility for maintaining the neighbourhood, but also transferred the municipal budget reserved for these tasks to the resident's association. A neighbourhood maintenance fund was created which is managed by the residents; in meetings they decide how to invest the money in upgrading the neighbourhood.

4. People learn to build their own "passive" houses – Earthship

Earthship houses offer people in United Kingdom the opportunity to design and build their own homes and make a conscious decision to live lightly on the earth. The project disseminates technical competence in eco-building through workshops and gives people the opportunity to build their own homes. People can decide to start building or restoring their houses according to the design for environmental sustainability principles without having to ask for the input of professional consultants. Each home is a passive solar building, made from natural and recycled materials, is powered by renewable energy such as wind, water and solar power, harvesting its own water supply from rainwater, and treats its own sewage in planter beds. It is a concept and can be adapted for any climate worldwide. The purpose of Earthship is to inform people of the simple ways in which they can reduce their impact on the environment. The construction of Earthship houses (reclaimed tyres filled with compacted earth, with a glazed south-facing wall) allows thermal mass, maximum heat-retention and insulation. This is particularly appropriate for the Scottish climate, the most humid climate in which an Earthship has been built.

Fig. 3.39 'Building their own home' course[62]

62 Brighton Permaculture Trust (2022). Retrieved from: https://brightonpermaculture.org.uk/self-building-an-earthship/

Favouring /integrating the low-income, weaker and marginalised

When speaking about favouring and integrating the weaker and marginalised, we refer to a design that promotes the integration of certain people such as children, the elderly, disabled, unemployed, illiterate or people from any other marginalised social groups.

To understand in qualitative terms whether an existing system presents problems related to favouring and integrating weaker and marginalised groups, the following key questions should be asked:

- Does the supply system create obstacles or limit access to people with weaker social status (e.g. children, elderly, disabled etc.)?
- Is the offering system accessible to people with lower income?
- Does the offering system contribute in any way to the marginalisation of certain people?

Guidelines for favouring/integrating the low-income, weak and marginalised

- Offer the access rather than mere product ownership to extend the access even to low-income final user. **example 1**
- Complement the product offer with all-inclusive running costs (e.g. maintenance, repairs, upgrade, etc.) to avoid the interruption of use for low-income final users.
- Develop products or services that are accessible for free or at a cost that can be afforded even by low-income people. **examples 2**
- Diversify the offer and include options with higher and lower costs so that the access can be extended.
- Develop systems with shared economic property to increase their accessibility.
- Develop systems which promote labour services with equitable access/exchange. **example 3**

- Develop systems (e.g. cooperatives) which involve product sharing and cost reductions. **examples 4**
- Develop systems which allow easier access to credit (for companies). **example 5**
- Involve weaker people and improve their quality-of-life conditions. **examples 6**
- Involve marginalised people and improve their conditions by offering them qualifying jobs which enhances their competences.
- Involve foreigners and facilitate their settling in at the new social context/space.

examples

1. The toy libraries and Toy Library Association South Africa (TLASA)

Fig. 3.40 TLASA provides toy library information and recognised training to toy librarians[63]

63 TLASA (2022). Retrieved from: https://tlasa.org/

In a toy Library, a variety of toys, games, puzzles and educational aids can be borrowed in a way that is remarkably similar to a public library. Toy libraries may organise play sessions for families and also offer a wide range of toys appropriate for children at different stages in their development. Toy libraries provide children with new toys every week or two, saving parents money and keeping children from getting bored. Members have access to the stock list, sorted by age or development areas. Free advice is also supplied by toy library's personnel, during selection of the items and with other child related issues. Families who want to borrow toys from a Toy Library must become mem-

bers. Items can also be purchased after a “test drive” to guarantee that the child indeed finds the item useful. After choosing items, they can keep them for two weeks, then return and exchange them for two more toys. When the item is returned, it is checked to see whether everything is in order. The members are asked to clean the items before returning them, but the toy library also takes care of careful cleaning and hygiene check. Toys are selected to be durable, interesting, low maintenance and not likely to have many lost or broken parts. Toys without batteries and with not too many small parts are preferred. Usually, a website explains how items have been organised according to skills and ages, accompanied by photos of toys from the different categories. If the toy breaks, the action taken by the toy library depends on the importance of the damage. If a toy is completely broken or totally lost, the member must pay the replacement cost. If, however it is possible to fix the toy to be fully functional again, the toy library repairs it and just charges the member a penalty that will cover costs.

Items are used to their maximum potential, and they are no longer bought by one family, used and then discarded when not needed anymore. In this way, they are used many times. In other words, the use of toys and educational items is maximised to meet given demands: fewer products are needed, since this service makes the same product available for a higher number of people. From the consumer point of view, the economic benefit is evident since families do not need to spend a lot of money in buying toys that are to be changed within a short period.

Across the world, even in low- and middle-income countries, this system can be implemented successfully. Toy libraries have existed since at least 1935, with the establishment of one in Los Angeles. The idea re-emerged and gained popularity in the United States in the 60s and 70s with the passage of Head Start and other legislation. For example, the Toy Library Association South Africa is a networking organisation that promotes best practice in the field of toy libraries. They are a registered Non-profit organisation and as a multi-sectoral stakeholder forum representing toy libraries in South Africa, they influence Africa and the world’s perception of the role of toy libraries in society.

2.1 Solar Cooker International system

Open Solar Cooker is a clean, safe and cheap cooking system, easy to build and to use. Made of a parabolic reflective panel and of a plastic bag, it can be used like any other pot to cook or purify drinking water. Bigger and different kind of solar cooker are used by companies at health centres (to take care of safe medical means and warm up water) or schools (to cook food). It has been used also by bakeries, in processing honey, in silk production, or colouring clothes. There is an interesting new project in Kenya, where refugee women are spreading is kind of cooker to their neighbours. There is an international information organisation that helps to use it and develop the diffusion of this system. It organises the training and gives aid to adapt it to different weather situations and to cook different kinds of food. Cooker uses solar energy instead of wood. In this way is possible to use less than half of traditional combustible resources in sunny areas with a reduction in deforestation. It can be used to boil drinking water thus helping to avoid diseases caused by undrinkable water, one of the main causes of death among children in these countries. Open Solar Cooker can be built with a large range of recyclable and recycled material. Using solar energy lessens smoke and pulmonary diseases; there is no soot, food is not burned and does not damage pots, thus ease the workload and used detergent.

2.2 Crank handle radio - Bay Gen Power Europe

BayGen Freeplay is a hand powered radio and covers the FM, MW and SW frequencies. It does not need a battery nor electric current, being provided with 50/60 revolutions rechargeable generator.
The inventor, Trevor Baylis, was inspired by a television documentary about the difficult and insufficient communication in Africa, where radio is not widespread because of high electricity costs and bad battery supply. Trevor’s idea was to use human power instead of traditional energy sources. Everywhere in main audience points where aid is given to millions of people also these radios are distributed

by a new educational channel. After turning the crank for 60 times (this operation takes about 25 seconds) the radio would last for 40 minutes. If turned off before full exhaustion of the battery the electric system stores remaining energy thus enabling to use it immediately next time. Baygen Freeplay reduces consuming energetic resources because it is not powered with net electricity or cells during the usage, also reducing the need to produce, distribute and discard battery cells, a toxic device on its own.

Fig. 3.41 BayGen Freeplay[64]

64 Science Museum Group (2022). Retrieved from: https://collection.sciencemuseumgroup.org.uk/objects/co432265/baygen-freeplay-wind-up-radio-a-portable-receiv-wind-up-radio

3. Time banking

Time banking is a system of service exchange that uses units of time as currency, always valued at an hour's worth of any person's labor. It gives the possibility to meet other people and exchange one's own labour services and assistance with everyday life problems, on an equal trade basis without differences between different jobs. The exchange is a barter-based on hours, not on performance values. Each person hour has the same value. No money is used instead a special kind of check could be used to notify the amount of exchanged services. Essentially, the "time" one spends providing various types of community services earns the "time" that one can spend to receive

services. Different types of services can be exchanged, on the basis of what people can offer. Examples of services include reparation of electric faults, dinner call, English or other language conversations, animal or plant care. The aim is to satisfy the material and social needs of everyone in a cooperative and friendly contest. In fact, communities use time banking as a tool to forge stronger intra-community connections, i.e. building social capital. Time banking had its genesis in the US in the early 1980s, and today, 26 countries have active TimeBanks. In 2013 TimeRepublik launched global Timebank, aiming at eliminating geographical limitations.

Fig. 3.42 An image representing the Time Bank concept[65]

65 Pixabay (2022). Retrieved from: https://pixabay.com/illustrations/save-time-save-time-time-is-money-1667023/?download

4.1 Co-operative COVIAL - Vinicola Aurora, wine co-operative

COVIAL is a co-operative established within the Vinicola Aurora Ltda, and is the biggest wine market co-operative in Brazil. It is located in south Brazil, Bento Gonçalves, in the state of Rio Grande do Sul. COVIAL co-operative

has ten members: the manager, three agronomists, two technicians, one accountant, one secretary and two social assistants. The associates take part in the COVIAL decision making process through thirteen elected representatives who attend regular meetings of the co-operative. The COVIAL provides enabling platforms and provides a result-based service to its associates. It supplies technical equipment to work on the vineyards (available to be booked by associates) and purchases seedlings from Italy, France and South Africa. It also buys dung, herbicides and various pesticides, barbed wire etc. In bulk and resells these to associates. In addition, four agronomists and two technicians are at the associate's disposal, classes and training courses on vineyard management, pruning and grape- harvesting are organised. Associates pay for services, equipment and materials when they deliver their produce; a part of their final fee (dependent on their size) is held back to cover the running costs of the co-operative. The idea of having a cooperative within a production company such as Vinicola Aurora, arose to guarantee to associates the quality of grape seedlings coming from different suppliers, guarantee to associates that all their produce would be acquired (by the COVIAL), and to guarantee harvest quality to Vinicola Aurora. The outcome is that different wine producers have established a network and a structured service centre, to create their own self-sustaining Product-Service System. With its 1300 associates, the co-operative is no longer accepting new members as it has reached maximum viable participation. There is an advantage for associates because, from seedling plant out, until harvest and collection, they can get ready access to technical and logistic support from Vinicola Aurora. They obtain professional equipment and personnel (agronomists) support, at less than market price, and make cost savings because of COVIALS bulk buying of sprouts and herbicide etc. Risk is minimised for associates because of the guaranteed purchase of their harvest and for Vinicola Aurora because grape quality and quantity is assured. The assistance of agronomists and provision of training also leads to greater knowledge and consequent efficiencies. The environmental benefits are generated by the sharing

of technical equipment which leads to more intensive use, and access to more costly but efficient equipment than could be afforded by individual purchase.

Fig. 3.43 The COVIAL co-operative[66]

66 Vezzoli, C. (2010) System Design for Sustainability: Theory, Methods and Tools for a Sustainable 'Satisfaction-System' Design II edition (Milan, IT: Maggioli Editore)

4.2 Viavai - Sharing trips

This service favours private means of transport sharing for travels on medium-long distance. People involved:

- Travellers who do not have private means of transportation and who do not use public transport (train, airplane...). Reasons: they want to reduce costs, share planning and travelling.
- Travellers that hate private means of transportation and who want to share costs and meet new people.

The website and the participants are Italian, but foreign participation is allowed. Trips can take place all over Europe and they are organized in advance. It is an online service where people, who are looking for a car ride or are offering one, can exchange their addresses and telephone numbers. This kind of "prearranged hitch-hiking" gives:

- certainty to have a car ride (before the beginning of a trip)

- information about the other person
- prior agreement of costs sharing.

Before a person can answer to an interesting proposal on the board he has to register himself to the service and send a fax with a copy of his identity card, the inscription payment receipt and the proposal identification code. Viavai also gives information about trips, organizations, entertainments to registered and not registered people alike. People do not have to worry about driving alone, lonely trips, and taking public transport anymore. It helps start new friendships and allows people to share travelling experiences. And the environmental impact of private transport is smaller as well.

Fig. 3.44 Viavai - sharing trips[67]

67 Vezzoli, C. (2010) System Design for Sustainability: Theory, Methods and Tools for a Sustainable 'Satisfaction-System' Design II edition (Milan, IT: Maggioli Editore)

4.3 BlaBlaCar, carpooling platform

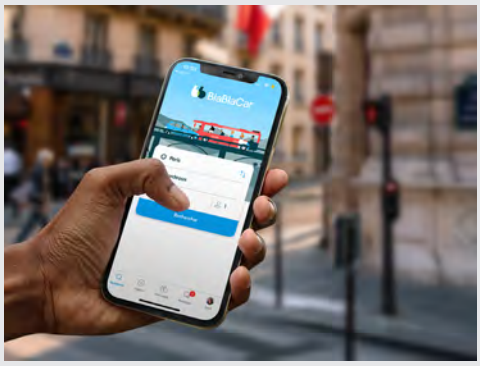


Fig. 3.45 App of the Carpooling service by BlaBlaCar[68]

68 Blablacar (2022)

BlaBlaCar is a platform for long-distance ride sharing, that connects drivers and passengers who want to travel together between cities sharing the cost of the journey. The driver can share the information of the route of the journey online on the platform and the passengers who wants to go on the same route can request drivers to join the ride. Thus, the platform lets users to connect locally through sharing information (Distributed Information, Distributed Services). The hardware that is used in the distribution of the information is mainly mobile devices but also computers. However, there is not PSS applied to this type of hardware within this service.

5. Banca etica - ethic bank

The Italian Banca Popolare Etica aims to actualize the idea of a bank that is a meeting point for savers, who share the need of responsible and conscious administration of their own money. They also share the idea of a sustainable developing model, in which the creation and the distribution of richness are founded on the values of the solidarity, the transparency and realisation of the common good. Banca Etica is aware of that the society's transformation goes through the productive systems transformation, In particular, it finances projects concerning social and environmental sustainability and gives the possibility to have access to credit for people, who want to start a project in these areas.

6.1 Adults are helped to recover from addiction - Coach House Trust

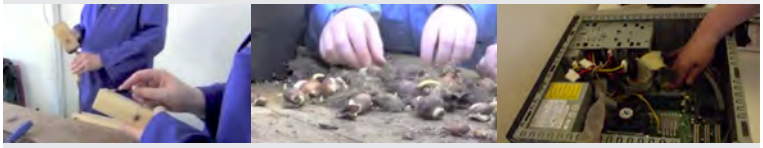


Fig. 3.46 The Coach House Trust provides structured workshops in Art, Gardening, Woodwork, Computing, Music and Healthy Eating[69]

The Coach House Trust is a non-profit organization in United Kingdom that seeks to challenge the economic and social exclusion of adults with mental health problems, recov-

69 The Coach House Trust (2022). Retrieved from: http://www.thecht.co.uk/index.html

ering from addiction or with learning difficulties who find it difficult to find and keep a job. The Coach House gives them focus and the opportunities to gain skills and be part of a warm community environment. The scheme provides personal, social and vocational development in places that can help reintegrate them into the mainstream community. It achieves this through providing indoor and outdoor workshops and activities such as ceramics, woodwork, gardening and recycling compost. Participants work in and with the local community, building mutual trust and respect and achieving integration. Products manufactured such as fruit and vegetables, woodwork and metalwork sculptures, paintings and silk paintings are sold in the shop. People who have experienced addiction or mental illness are regularly ignored in everyday society but are welcomed in the Coach House. It gives them opportunities to learn new skills, meet new and similar people and help by taking part in sustainable practices, such as woodwork, mosaics, metalwork, slab- making, furniture-making, gardening and recycling. Much of this work benefits the local society. The team renovates public spaces and landscapes local private gardens. The non-profit organization is funded by various bodies, such as the health authority and charities. Regular attendees must have funding, which goes towards training, materials and equipment and staff. It would be hard to find enough funding for the trust to expand, even if it wanted to, meaning that new clients are increasingly unable to join or participate. Any work sold through the shop or restaurants/ markets goes towards materials/tools etc.

6.2 Co-housing for over 55 – Aquarius, Eindhoven housing society

Fig. 3.47 Aquarius is a community where elderly people spend their days in a socially active environment[70]

70 Meroni, A., (2007). Creative communities. People inventing sustainable ways of living. Edizioni POLI.design, Milano. https://www.strategicdesignscenarios.net/downloads/Publications/Creative%20Communities.pdf

Acquarius is a community made by 45 aged persons who live in separated but close houses, helping each other according to different possibilities. The community block is made by 30 private two-stored houses with garden, plus a big common room with shared kitchen and a large park. Acquarius association has, among its duties, that of knowing new potential users and of doing a first selection. The preference goes to persons between 55 and 65 years, active and available for self-help. Living in a community stimulates social relation and active keeping, it provides inhabitants with a safety feeling, with benefit for them and their families, and lighten public structures from care services, often avoidable.

Improving social cohesion

Improving social cohesion denotes a design promoting and favouring systems that propitiates social integration: in the neighbourhood, between generations, between genders and between different cultures.

To understand in qualitative terms, whether an existing system presents any problems related to improving social cohesion, the following key questions should be asked:

- Is the offering system creating or promoting any form of intra-gender, intra-cultural, intra-generational marginalisation?
- Is the system creating any forms of discrimination (sexual, religious, cultural, gender)?

Guidelines for improving social cohesion

- Promote products, spaces, infrastructures, knowledge, service sharing systems that enable neighbourhood/social integration. **example 1**
- Promote systems of sharing common goods and their maintenance within neighbourhoods.
- Promote co-housing systems.
- Promote systems enabling inhabitants to co-design common goods. **example 2**

- Promote products, spaces, infrastructures, knowledge, service sharing systems that enable social integration between generations. **example 3**
- Promote products, spaces, infrastructures, knowledge, service sharing systems that enable gender integration.
- Promote products, spaces, infrastructures, knowledge, service sharing systems that enable social integration between different cultures. **example 4**

examples

1. Ecological and shared city district: Vauban

Vauban is a neighbourhood of Freiburg (southwest of Germany) which was specifically planned and built as a sustainable urban distinct. This area, where old military barracks used to be during the Second World War, was restored based on ecological and social cohesion criteria. The goal was to build houses designed for people with different lifestyle and social backgrounds as a cross-over of working and living functions close to the city centre. It includes co-housing matched with social and environmental projects. Vauban sustainable district development has been promoted by “Forum Vauban”. “Forum Vauban” organises working teams, information campaigns and other activities related to district development. Citizens take part in the management by working with teams to discuss transport, energy, and communal living issues. Vauban implemented a successful model for alternative mobility. The district is entirely car-free, and traffic is prohibited in most streets. Green areas and public spaces are prioritised, which play an important factor in the community’s social cohesion. Most houses have been built by SUSI co-operative in an environmentally orientated way based on renewable energy, energy efficiency and bioclimatic architecture principles. The neighbourhood acts as an aggregation and co-planning point. The quality of life is very high; in fact, citizens’ cooperation has helped to create a district that meets the needs of its inhabitants. Sustainable urban districts like

this help develop people's autonomy while diffusing environmental awareness and promoting sustainable living at the same time.

Examples of high levels of environmental sustainability within the district:

- Energy: 25% less energy consumption than in the rest of Freiburg; some houses produce more energy than they need and distribute it across the district; active solar energy use.
- Transport: reduced the use of car transport; it is not only a car-free neighbourhood but also a parking-free zone. The limited number of private cars can only be parked near the district entrance; priority is given to pedestrian and bicycle mobility within the neighbourhood.
- Homes: self-built houses at lower economic costs; technical training on bio-architecture; bio-architecture principles applied in construction and maintenance.
- Water: using natural disposal and rainwater; bio-gas generation from garbage.

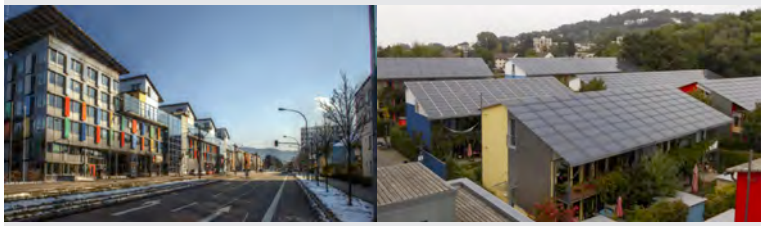


Fig. 3.48 Sustainable Urban District Vauban[71]

2. Quirky

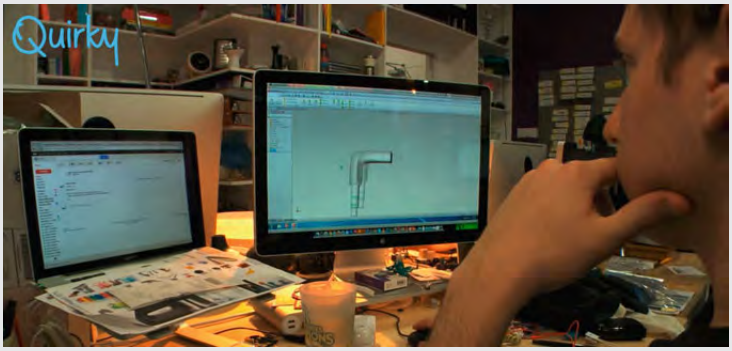


Fig. 3.49 Quirky invention platform[72]

71 Left figure: © Sromuald; Right figure: © Arnold Plesse. Retrieved from: Urban Sustainability Exchange (USE) case study section (2022). https://use.metropolis.org/case-studies/sustainable-urban-district-vauban

72 Vezzoli, C., Garcia, B. and Kohtala, C. (2021) Design sustainability for all: the design of sustainable product-service system applied to distributed economics. S.L.: SPRINGER NATURE.

Quirky is an invention platform that connects inventors with users who has other skills for developing the idea and with the companies that specialized in a specific product category for manufacturing. “According to the Economist, Quirky offers users’ access to a complete product creation enterprise. The business model of Quirky incorporates the originating designers into the wealth-sharing model and provides them with a portion of the profits that their products yield.”[73] The users don’t need to pay for using the platform. The users can submit their ideas and connect with other to make a team for collaborating. Once the developed idea is accepted by Quirky through a voting system by the Quirky community at Eval (Quirky’s live weekly product evaluation), it is pitched to the manufacturers. If it gets manufactured, Quirky shares the profit with the team members according to their influence evaluated by a point system of Quirky platform.
In terms of socio-ethical benefits, the platform generates profitability for companies, since it creates new work for manufacturers. Moreover, it enables individual inventors to get long term revenue without risking their economic capital, reducing business risks.

73 The Economist (2012). Retrieved from: https://www.economist.com/special-report/2012/04/21/all-together-now

3. Low Cost Intergeneration flat-sharing in the EHPAD

In order to reduce the isolation of many seniors, tackle the precarious housing situation of many students, and create greater social cohesion in the neighbourhood, CCAS (communal centre for social action), has implemented a low-priced (from 190 to 290 EUR) intergenerational flat-sharing project in three of its seven nursing homes (the so-called EHPAD is the most widespread type of French Residential care for senior citizens) for eleven students.
In exchange for a low-priced apartment (renovated former company apartment), the students must volunteer and work for three hours per week. Each month, students are offered a schedule of at least three hours of intergenerational activities per week, depending on their availability and areas of interest. The objectives are to provide very low-cost housing for students; to develop a year-round intergenerational project; and, to open nursing homes in

various neighbourhoods and develop them into active intergenerational spaces. These new roommates will be able to share moments of conviviality with the residents but also discover more about life for themselves. For residents, this will be an opportunity to share their experiences and benefit from the vitality and dynamism of younger generations. The renovation, maintenance, and rental of functional apartments within nursing homes enables the efficient management of the CCAS's real estate assets. The redistribution of the rent collected by the CCAS of Montpellier to intergenerational student/senior workshops also improves the quality of life for the residents and helps create social cohesion. Moreover, the strong media impact of this project has made it possible to enhance the image of the nursing homes as places to live that are also open to the neighbourhood. From this project, a chain of solidarity is being activated. The apartments have been renovated by a group of young people, as part of a citizen's project, for the use of other young people who will themselves be involved with senior residents, creating a chain of intergenerational citizenship

4. Italian language teaching to foreigners - "Millevoci" association - Fano-Pesaro Urbino

Millevoci association was created in Fano (Italy) as a volunteer association that offers Italian language teaching for free to foreigners from any country or social class. The association is mostly made by homemakers, former primary school teachers but also professional men and young people. Its main goal is to facilitate integration between new and old families, in order to guarantee better quality of life for both foreigners and native Italians.
The municipality does not have to sponsor the association besides providing the stationery.

Empowering/enhancing the use of local resources

Empowering/enhancing local resources denotes a design that promotes and favours systems that regenerate and empower local economies.

To understand in qualitative terms, whether an existing system presents any problems related to enhancing the use of local resources, the following key questions should be asked:

- Does the current reference system impoverish local cultural values and identities?
- Does the current system offer only one solution/few variations for all regions and cultures?
- Does the current system have a negative impact on the social well-being of the local community?
- Is the current system impoverishing local economies?
- Is the system absorbing local non-renewable resources?

Guidelines for empowering/enhancing local resources

- Offer the access rather than the ownership of equipment to extend the access even to low and middle-income local entrepreneurs. **example 1**
- Complement the equipment offer with all-inclusive services covering running costs (e.g. maintenance, repairs, upgrade, etc.) to avoid the interruption of use by low and middle-income local entrepreneurs. **example 2**
- Offer the access rather than the ownership of distributed/decentralised production systems (energy generation, food production, water management, manufacturing, software development, information/knowledge generation, design) to extend the access even to low and middle-income local entrepreneurs. **examples 3**
- Complement offers for distributed/ decentralised production systems (energy generation, food production, water management, manufacturing, software development, information/knowledge generation, design) with all-inclusive running cost (e.g. maintenance, repairs, upgrade, etc.) to avoid the interruption of use by low and middle-income local entrepreneur/organisation.

- Reinforce the role of the local economy in creating services in the same place where they will be used. **example 4**
- Favour any development that enhances local capacities for collaborated production of goods that contribute to the common goods and external economies. **example 5**
- Renew/ regenerate urban artefacts that have fallen into disuse (by involving the weak and marginalised). **examples 6**
- Renew/ regenerate industrial, domestic and urban dismissed products and materials. **examples 7**
- Adopt/ promote systems using regenerated natural, local resources. **example 8**
- Respect/ enhance peculiar locally-based activities enterprises. **example 9**
- Respect and encourage cultural identities and diversities.

examples

1, 2. Solarkiosk, Ethiopia and Kenya

Fig. 3.50 Solar Kiosk[74]

The company targets local entrepreneurs, especially women, for the provision of energy services through charging stations. Solar

74 Vezzoli, C., Garcia, B. and Kohtala, C. (2021) Design sustainability for all: the design of sustainable product-service system applied to distributed economics. S.l.: SPRINGER NATURE.

kiosk design and installs the E-Hubb, a charging station provided with solar panels and energy using products and recruits a local entrepreneur who manages the system and appliances. Due to the modular configuration of the station, he/she can provide a wide range of energy services such as internet connectivity, water purification, copying, printing and scanning etc. Customers pay for the service they need: pay to print, pay to get purified water, pay for internet access, etc.
Furthermore, the Solarkiosk E-Hubb, is offered with all-inclusive services covering running costs of maintenance and repairs.

3.1 Bio-mercatino - The little organic market

Bio-mercatino is a street market in Milan (Italy) that gathers small local organic producers from Lombardia and nearby regions. Around 45 stands of producers and retailers sell certified organic products like vegetables, fruits, cheese, sausage, honey and olive oil. Crafts, non-treated cotton clothes, herbal products and books about culinary and natural medicine are also sold. The stands of all shapes and sizes are assembled by the retailers, who will also clean the area afterwards. VAS (Verdi Ambiente Società), an environmental protection association supporting a healthy and environmentally responsible lifestyle, promotes the market by co-ordinating the work of producers, retailers, artists, craftsmen and volunteers. It also obtains the necessary permits from the public administration, supervises the market and communicates the initiative to the public by sending press releases to newspapers and radio stations. Bio-mercatino promotes an urban healthy lifestyle by enabling city inhabitants to be better informed and to buy organic and safe food directly from farmers. It also contributes to the survival of local producers, promotes a conviviality not found in city supermarkets and re-connects city and countryside. The market, which gets only minimum support from public institutions, provides a new and alternative retail channel for small organic producers and retailers. Farmers can earn more for their work and consumers can find organic food at competitive prices compared with other specialist shops or supermarkets. The production of organic food, avoiding the use of genetically modified seeds and pesticides and following organic and season-

al cultivation techniques, reduces pollution, preserves the landscape and safeguards biodiversity. As all the food in the scheme is grown locally, the reduction of food transportation radically reduces the environmental impact of the food chain.

3.2 Solidarity Purchase Group - Lambrate GAS (Gruppo di Acquisto Solidale)

A Solidarity Purchase Group replies to the need for a different way of consumption: buying collectively and democratically. A group of people that has decided to reconsider their consumption habits and to purchase together their everyday products, with the following priorities:

- preference for local, seasonal and biological produces
- preference for small local producer and social cooperatives
- direct contact with suppliers' production site
- cost reduction duet to de-intermediation.

For example, the Lambrate GAS (Gruppo di Acquisto Solidale), established in 2000 in Milan (Italy), has currently 40 members organized in different work groups. They give priority to political-social criterion over naturalistic- organic ones. To obtain better prices they are buying in big quantities and try to bypass several links in distribution chain. They contribute to the survival of local producers. While respecting and promoting local and organic work, they help to reduce pollution and energy consumption caused by transportation.

3.3 Ecopantry - production and sale of biologic goods (Peeter Jalakas, Ö kosahver founder)

Ö kosahver is a no-profit company that deals with retail and wholesale market of controlled organic products. For the time being the service works in the two main Estonian cities (Tallinn and Tartu). It has been founded by a small circle of friends as an answer to people's attention in biologic local food, that were difficult to find. The most important product is a "foodbox" that contains 10 kinds of "foodsupplies" (above all vegetables, but also honey, bread and ar-

omatic herbs).
The “foodbox” satisfy the weekly need of four members family and it can be booked once a week both by telephone and on internet. The products arrive mainly from local organic producers. Customers receive information about “food- box” content by e-mail. The same information can be read in Ö kosahver homepage. The delivery happens on Wednesday or Thursday. The repository of Tallinn acts like a shop. Products bought are pasta, rice, sugar, olive oil, vegetables, cleansers, preserves, etc. Technological tools used are internet and telephone to order.
The organization encourages little organic producers by food delivery and by information about organic products. In this way they promote new form of sustainable agriculture, biodiversity and local production. Local distribution reduces transportation and the environmental impact associated with it.

Fig. 3.51 The ecopantry[75]

3.4 Organic food delivered to home - Local food link Van Group

Local Food Van Link, in association with other groups, helps increase local food production by distributing produce around 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, pick-

75 Meroni, A., 2007. Creative communities. People inventing sustainable ways of living. Edizioni POLI.design, Milano. https://www.strategicdesignscenarios.net/wp-content/uploads/2012/01/EMUDE_Creative-communities.pdf

ing up the orders from the producer and delivering them to their customers. By doing so, not only one could 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.

Fig. 3.52 Van Group's Food van[76]

76 Vezzoli, C. (2010) System Design for Sustainability: Theory, Methods and Tools for a Sustainable 'satisfaction-system' Design. Maggioli.

The Food Link Group aims to build strong sustainable networks between local producers and consumers to stimulate local food production. They believe that there are sound economic, environmental, health and community benefits to be gained from sourcing food directly from where it is produced. 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 schemes future aim is to both reinforce the notion of self-sufficiency through local produce and increase co-operation between producer and customer on the other. Making such high-quality food available to local people and visitors encourages aspects of local and family economy and ensures the future of sustainable agriculture on Skye. 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 of energy for cooling and freezing.

3.5 Open source (copyleft) software - Mozilla Public License

Copyleft is a wordplay on the term copyright and covers the Open access practice of using copyright law to remove restrictions on the distribution of copies and modified versions of a work for others and require that the same freedoms would be preserved in modified versions. Most commonly, open access is implemented by a license defining specific copyright terms applied to intellectual property such as computer software, documents, music, art, etc. Whereas copyright law, by default, automatically restricts the right to make and redistribute copies of an author's work, an open access license uses copyright law to ensure that every person who receives a copy of a work has the same rights to study, use, modify, and redistribute both the work and derived versions of the work as long as the same license terms apply to all redistributed versions of the work. Thus, in a non-legal sense, open access is the opposite of copyright, i.e. copyleft. In a legal sense, however, copyleft is based on the right of the author to impose copyright restrictions via a copyright license on those who want to use the work. Under an open access form of copyright license, the restrictions imposed are that the work can be copied, modified or used in any subsequent work if, and only if, the author of that subsequent work agrees to grant the same copyleft rights to the public to freely copy, use and modify the subsequent work. For this reason, copyleft licenses are known as reciprocal licenses. One of the first examples is the Mozilla Public License (MPL), an open source and free software license. Version 1.0 was developed by Mitchell Baker in 1998 when she worked as a lawyer at Netscape Communications Corporation and version 1.1 at the Mozilla Foundation. The MPL is characterized as a hybridization

of the modified BSD license and GNU General Public License. The MPL is the license for the Mozilla Application Suite, Mozilla Firefox, Mozilla Thunderbird and other Mozilla software. The copyleft license gives the possibility for all to have access to a source of information, and to modify and redistribute it.

Fig. 3.53 Copyleft symbol[77]

77 Wikipedia (2022). Retrieved from: https://es.wikipedia.org/wiki/Copyleft#/media/Archivo:Copyleft.svg

4. Production and usufruct of food farming goods "Adopt a sheep, defend nature"

Fig. 3.54 Making cheese with sheep milk[78]

78 La Porta dei Parchi (2022) Retrieved from: https://laportadeiparchi.com/

To satisfy the increasing attention towards food origin, processing and raw material it allows consumer to be part of the production and usufruct of food farming goods. The farming business has also found a sales method, while safeguarding traditions, farming knowledge and Italian

environmental resources. User gets a fair price, reliable and traceable products and learns about unknown contexts. The user has an annual cost of 75-190 euros. He can check his animal and its farmer's activities over the whole period. Eventual products are delivered to his home, or he can pick them up at the farm, further discounts follow, in case he volunteers for short time for seasonal work at the farm (e.g. sheep-shearing). This initiative safeguards the Abruzzo shepherd communities. Their knowledge and craft are at risk to be lost. This solution gives them some economic safety and for the consumer a possibility to save up to 12% on similar products.

5. Incubadora Tecnológica de Cooperativas Populares – Brasil

Since 1999 in Brazil, within the university has been established a network of Popular Co-operative Technological Incubators (ITCP). These are part of the university corpus and have the aim of creating new jobs for groups of people with low incomes, in a perspective of local development and in a context of a solidarity economy, through the dissemination of technical and scientific know-how produced within the university.

The idea of self-organization, of work teams is the basis of the "incubadora". It addresses to unemployed people and workers active in informal sector saying, that organizing themselves helps them to enter in organized society. This project acts on several fields: pedagogy, psychology, economy, administration, law, technology, enginery, design. The "incubadora" organises courses on cooperative ideas, on company administration, on accounting, on technology and design at different levels. Economic feasibility analysis is part of the "incubadora" activity. Work stages: community knowledge base (resources and problems setting); ability recognition (understanding and identification of suggestions, people identification); incubation (training on legislative, structural and administrative aspects of co-operative movement, surveys of economic feasibility, company formalisation); education (literacy, maths, specific

studies); incubation state development (advanced technical education (marketing, advertising...), market penetration, economic and formal aspect regularization). Some cooperatives founded in the field of Incubadora of Federal University of Paraná are: COEMBRA Cooperativa de Embalagens Brazil; COPTECH Cooperativa dos Profissionais em Tecnologia de Informática do Paraná; COOPERMANDI Cooperativa de Produtores Rurais e Artesãos de Mandirituba. Social benefits are generated by the whole development of involved communities, evaluating people and their management abilities, creating job opportunities and the improvement of living conditions.

6.1 Fair rents/ house leasing - DarCasa onlus

Dar Casa is an answer to the dwelling demand of otherwise excluded families, a building trade cooperative that renovates and rents out redecorated flats to poor families at low prices. The system works in this way:

1. The Aler enterprise (Azienda Lombarda Edilizia Residenziale Milano) rents to Dar Casa, at low price uncomfortable, decadent buildings in outlying areas, that it does not want to renovate itself.
2. The cooperative renovates the building with the money from sponsors (Chiesa Valdese, Fondazione Cariplo) in form of lending or remunerated fund.
3. Dar Casa assigns flats in change of an admission fee (51 Euro) and a monthly lease. The lease is the same that it pays to Aler plus a percentage according to the costs of renovation.
4. Alternative funding is also provided by the donations of the members.

It is socially functional for families otherwise unable to pay a lease. A house, as a job, allows a complete integration in the society. To own a house means a more constant, safer and calmer life. It allows people to be part of a community, to be socially integrated. It keeps high customer dignity. The cooperative uses social lending or free grants; they proceed from the starting point that renovation is in any case cheaper than buying/building one. Flats are also the fresh start for decadent and dismissed buildings. Renova-

tion helps the gentrification of the city and lessen the need for new plots, which would otherwise occupy the green areas or create new suburbs. Dar Casa matches social and environmental problems. With new cooperatives and sponsors, the association can expand further, and its method can be used also in other cities. There are two websites and a quarterly magazine (for customer information). Adaptation of new information technologies could help to further the aims of the association.

Fig. 3.55 Darcasa refurbished and assigned apartments as part of the Quattro Corti redevelopment project, Milan[79]

79 DAR=CASA (2022). Retrieved from: http://www.darcasa.org/portfolio/stadera-2/

6.2 Torri Superiore eco-village - Associazione Culturale Torri Superiore

The village is made of 160 bays with vaulting arch-attics linked by a complicate labyrinth of staircases, terraces and alleys (near Ventimiglia, North Italy). Nowadays the village is almost totally reorganized and open to ecological, cultural and association (e.g. Legambiente projects) touristic programs.
The permanent community is composed of 11 adults (two Dutch families, an Italian family and one single) and 5 children. All meals are shared and there is a weekly democratic assembly to discuss the common choices. Cultural and cooperative association members own a big part of the village. The rest is owned by individuals who live there in summertime. The community organises the cultural activities and welcomes the new members. Since several years they are running a biological agricultural project, they grow

enough fruits and vegetables to satisfy the internal demand, while oil is also sold. “Casa per ferie”, administrated by 5 members of Torri, is a building, where volunteers and tourists are hosted, and it sustains cooperative activities (the price for a night in “casa per ferie” is about 35 euros). Torri Superiore bids theoretical and practical courses on sustainability, community life, self-care and local territory with the following aims:

- to develop a sustainable recovering of the local area on the base of bio-architectural and bio-agriculture ideas;
- to develop sustainable tourism;
- to spread information on environmental sustainability;
- to share experiences, decisions and childcare.

Fig. 3.56 Solar panel in the Torri Superiore eco-village[80]

80 Vezzoli, C. (2010) System Design for Sustainability: Theory, Methods and Tools for a Sustainable ‘satisfaction-system’ Design. Maggioli.

7.1 Clearing out and scraps recovery - Cooperative “Di mano in mano”

“Di Mano in Mano”, based in Milan (Italy), has its roots in shock work of Villapizzone community that belongs to “Associazione Comunità e Famiglia”. The community consist of families opened to host poor children and adults. “Di Mano in Mano” co-operative aids communities with clearing out, recycling and green area maintenance activities, clearing out is their main activity that aims to recover waste and furniture, renovate and sell it in second-hand markets.

Together with Caritas Ambrosiana and Como Caritas they promote a project “Arriviamo” that provides housing for poor people.

Fig 3.57 The model of Di mano in mano[81]

81 LeNS (2022). Retrieved=ved from: http://www.lens-international.org/

Affiliated cooperative “Di Mano in Mano Solidale” consists of two main activities, gardening and picking up used clothes.
“Di Mano in Mano Servizi” is a benchmark and a source of help in management and financial field for the families belonging to the Communities and for a few outsiders (the small number is due to the prohibitive amount of work). They offer high quality services reducing costs and allowing people to do a better use of their time, satisfying their needs. Now it operates like a professional activity but preserves its original social attitude. Nowadays the sustainability issues include both environmental and social aspects: waste is a signal of depreciated wealth and a collective damage. In fact, it spotlights the reduced environmental quality and squandering of human and material resources. Our society is looking for a solution. The cooperative solution is a service focused on re-use and recycle of goods; organized projects also offer job opportunities to unemployed people. Social aims are local civil society development; generation of social assets makes accessible cognitive, emotional and strategic resources; co-operation and mutual trust as main features of social progress.
The activity is self-sufficient thanks to profit gained from services: 70% of the proceeds comes from second-hand

market, 30% comes from clearing out, renovating and gardening activity.

7.2 Precious plastic

Precious Plastic is an open-source project which shares the blueprint of developed machines to recycle plastic waste to produce new products. The machines include a plastic shredder, extruder, injection molder and rotation molder. The processes are grinding plastic waste into small plastic chips, melting the plastic and manufacturing new products with it. There is also an online platform (davehakkens.nl/community/forums) for the community to share and exchange ideas. It is explained on the website as “See it as an online makerspace, an open innovation think tank, a place where you can brainstorm, share suggestions, try out solutions and help innovate.” So, everyone can contribute to the design of the recycling machine and designs for producing various final products.

8. Palm-leaves veins furniture - Ain Shams University Egypt

In Egypt the annual date palm pruning consists in picking their leaves. These leaves have though and woody veins. They can be changed in plank with mechanical features like those of fir and beech tree and they can be used to make screenings, tables and other pieces of furniture. This material can be used directly, or it can be shaped like boards to make furniture using local technology. The Egyptian university Ain Shams has designed furniture made of central ribbing. The materials used are renew- able and processable with suitable technologies. Wood is a rare material in Africa, and it has to be imported with a high environmental cost due to transportation. In these areas instead there are a lot of date palms that can provide an alternative material to wood. It is possible to avoid environmental and economic costs caused due to foreign wood purchasing.

3.3 Strategies, guidelines and examples to design S.PSS applied to DE

Here below can be found a set of strategies and then a set of relative guidelines to support the Design of DE as an S.PSS model.

- **Complement DE hardware offer with Life Cycle services**
- **Offer ownerless DE systems as enabling platform**
- **Offer ownerless DE systems with full services**
- **Optimise stakeholder's configuration**
- **Delink payment from hardware purchases and resource consumption**
- **Optimise DE structure**

Guidelines for complementing DE hardware offer with Life Cycle services

- The provider/s complement the DE hardware offer, with financial services to support initial investment and eventual maintenance and repairing costs, i.e. micro-credit, crowd funding, donation. **example 1**

- Complement the DE hardware offer, with support services for the design and/or installation of its components (i.e. DG: the micro generator, the storage, the inverter, the wiring, etc.). **example 2**
- Complement the DE hardware offer, with support services during use, i.e. maintenance, repairing and upgrading of its components. **example 3**
- Complement the DE hardware offer, with support services for the end-of life treatment of its components.
- Complement the DE hardware offer, with support services to enable the customer to either design or produce with their DE hardware, share their de hardware, sell/provide their production, provide services through their de hardware.

examples

1. Microcredit system - Grameen Bank

The Grameen Bank is a micro-finance organization started in Bangladesh that gives small loans (known as microcredit) to the unemployed, to poor entrepreneurs and to others living in poverty, who cannot be represented by a regular bank. These individuals lack collateral, steady employment and a verifiable credit history and therefore cannot meet even the most minimum qualifications to gain access to traditional credit. The system is based on the idea that the poor have skills that are under-utilized. The bank also accepts deposits, provides other services, and runs several development-oriented businesses including fabric, telephone and energy companies. The organization and its founder, Muhammad Yunus, were jointly awarded the Nobel Peace Prize in 2006.

2. Arduino

Arduino is an open-source prototyping platform based on easy-to-use hardware and software. Arduino boards can read inputs - light on a sensor, a finger on a button, or a

Twitter message - and turn it into an output - activating a motor, turning on a LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language, and the Arduino Software" (arduino.cc) Arduino can be used in distributed production of electronic hardware. Some of the sort of areas of projects Arduino used are building DIY 3D Printers, robotics, internet of things and wearables. Its easy-to-use interface, low price, high compatibility with wide range of platforms and availability of large variety of information and codes provided by the community make it possible for wide range of users to use Arduino in development of complicated projects. Estimated of 700.000 official and 700.000 unofficial Arduino boards were in use by 2013.

3. Bboxx

Fig. 3.58 Part of the solar home system provided by Bboxx presented by an employer[82]

BBOXX, founded in 2010, has built up 42 shops across 3 countries in Africa, where its sells its own Solar Home Systems (SHS) and related accessories, including a platform called SMART Solar to monitor energy use and the performance of the systems. Customers pay a monthly fee (from 10 to 20 USD) to access energy for the whole day, depending on the dimensions of the system. After around

82 Vezzoli, C. et al. (2018) Designing Sustainable Energy for All. Cham: Springer International Publishing (Green Energy and Technology).

3 years of payments the Solar system is owned by the customer. Installation and services as maintenance and repair are included in the fee and done by BBOXX's local technicians. After complete repayment, the customer can go for a maintenance contract which means he/she continues to get support and replacements for the unit.

Guidelines for offering ownerless DE systems as enabling platform

- The provider/s complements an ownerless offer of the DE system with training/information services to enable the customer to design the DE hardware / its components.
- The provider/s complements an ownerless offer of the DE system with training/information services to enable the customer to maintain, repair one or more DE hardware / its components. **example 1**
- The provider/s complements an ownerless offer of the DE system with training/information services to enable the customer to install one or more de hardware / its components.
- The provider/s complements an ownerless offer of the DE system with training/information services to enable the customer to upgrade one or more de hardware / its components.
- The provider/s complements an ownerless offer of the DE system with training/information services to enable the customer to use-optimization of one or more de hardware / its components. **example 2**
- The provider complements an ownerless offer of the DE system with services to enable the customer to either design, produce with their DE hardware, share their DE hardware, sell/provide their production, provide services through their DE hardware. **example 3**

examples

1. Solarkiosk – Ethiopia, Kenya

The company targets local entrepreneurs, especially women, for the provision of energy services through charging stations. Solarkiosk designs and installs the E-Hubb, a charging station provided with solar panels and energy-products, recruits and supports a local entrepreneur to manage the system and appliances. Due to the modular configuration of the station, he/she can provide a wide range of energy services such as internet connectivity, water purification, copying, printing and scanning etc. Users pay for the service they need, such as pay to print, pay to get purified water, pay for internet access, etc.

Fig. 3.59 Sample of structure provided by Solarkiosk to local enterpreneurs[83]

2. Techshop – USA

Techshop was chain of co-working spaces/workshops that provides access to use of industrial tools and equipment. Their CEO, Mark Hatch describes Techshop as “membership-based DIY fabrication studio and workshop” and says they are “democratizing access to the tools of industrial revolution.” BBC describes it as “growing network of

83 Vezzoli, C., Garcia, B. and Kohtala, C. (2021) Design sustainability for all: the design of sustainable product-service system applied to distributed economics. S.l.: SPRINGER NATURE.

open access manufacturing workshops." The equipment and tools they provide includes but not limited to milling machines and lathes, laser cutters, sheet metal equipment, welding equipment, an indoor automotive work bay, woodworking equipment including a 4' x 8' CNC (computer numerically controlled) ShopBot router, plastics working equipment, hand tools, 3D printers, CNC vinyl cutters, sewing machines, design software. The member can use any equipment just by paying the membership fee which is $150 per month. They claim that members have access to over $1 million worth of advanced machines and tools, sophisticated 2D and 3D design software, and other professional equipment.

Fig. 3.60 Techshop workshop space and tools[84]

84 LeNS International (2022). Retrieved from: http://www.lens-international.org

3. Kitchentown – San Mateo, California, USA

KitchenTown is an 11,000 square foot shared-space processing kitchen and an incubator opened to serve the needs of small food produces who produces locally made small-batch products. It provides users space as well as specialized high-end equipment to streamline food production, packaging and storage. It is aimed at mainly food production start-ups and food makers who are looking to scale. They also help the makers with production, machinery operation and shipping. Users of the service pay a $150 monthly fee plus an hourly rate ($30 an hour) for the use of facilities. The makers can schedule time to use the facilities and employees to make their products.

Fig. 3.61 Kitchentown equipment and spaces[85]

85 Kitchentown (2022) Retrieved from: https://kitchen-towncentral.com/

Guidelines for offering ownerless DE systems with full services

- The provider/s complements an ownerless offer of the DE system with support services to design the DE hardware / its components. **example 1**
- The provider/s complements an ownerless offer of the DE system with support services to maintain, repair one or more DE hardware / its components.
- The provider/s complements an ownerless offer of the DE system with support services to install one or more de hardware / its components. **example 2**
- The provider/s complements an ownerless offer of the DE system with support services to upgrade one or more DE hardware / its components. **example 3**
- The provider/s complements an ownerless offer of the DE system with support services for the use-optimization of one or more DE hardware / its components.
- The provider/s complements an ownerless offer of the DE system with support to either design, produce with their DE hardware, share their DE hardware, sell/provide their production, provide services through their DE hardware. **example 4**

examples

1. OMC Power

OMC Power offers energy solutions to telecommunication companies, through large stand-alone power plants running on solar, wind and biogas. OMC Power builds, owns and operates power plants and smart mini-grids to serve telecom companies, businesses and communities in rural off-grid areas.
Telecommunication companies get the power plant installed on site and pay according to the energy they use (kWh). OMC Power retains the ownership of the energy system and provides operation and maintenance. As com-

plementary service OMC Power offers charged lanterns to local communities (pre-payment or pay-per-use). They offer customised packages to suit customers' pockets. OMC Power charge less than the existing household budget for kerosene and mobile charging and enable people to climb the energy ladder.

2. Off-grid: electric

The M-POWER, a private company operating in low middle-income contexts around Africa, offers to Tanzania rural people Solar Home Systems (SHS) based on an innovative Business to Customer offer. The offered SHS, includes the hardware to generate solar energy (Solar panel + Storage + Wires) and the related Energy Using Products (EUP) (two lights + phone charger) to supply daily life energy needs. Customers pays as a pay per period with a daily fee, thus facilitating money expenses and consequently the energy access. OFF-GRID Electric retains the ownership of SHS and EUPs including their maintenance and repair, so forth cutting both the initial investment and unexpected expenses (e.g. repair and maintenance) for the customer. Furthermore, OFF-GRID Electric organizes trainings for a network of local dealers for installation and customer support, fostering local empowerment and employment and has recently opened the first OFF-GRID Academy for technical training.

3. Microsoft - Patent for pay-as-you-go

Microsoft patented a pay-as-you-go computing model "A computer with scalable performance level components and selectable software and service options has a user interface that allows individual performance levels to be selected. The scalable performance level components may include a processor, memory, graphics controller, etc. Software and services may include word processing, email, browsing, database access, etc. To support a pay-per-use business model, each selectable item may have a cost associated with it, allowing a user to pay for the services selected and that presumably correspond to the task or tasks being per-

formed. An administrator may use a similar user interface to set performance levels for each computer in a network, allowing performance and cost to be set according to a user's requirements." This patent which allows users to pay for use can be used in distributed economies such as Distributed Information (DI), Distributed Software (DS) and Design (DD) where the production of the information/software and the design is made using a PC. The service could be provided in form of bundles of software and hardware for various purposes such as office, gaming, and browsing.

4. Xometry online marketplace

Xometry is an online marketplace that connects makers with manufacturers, factories and assembly lines, offering up unused production capacity to companies of all scales. A buyer uploads a project file online on the website of Xometry. Xometry responds with a quote which includes machining, materials, and logistics costs. Upon approval by the buyer, Xometry places the project with suppliers whose availability corresponds with the project needs. Xometry manages production, material procurement, delivery and payments. Xometry ensures that the manufacturers qualify for high quality production and guarantees the quality of the production. The machines MakeTime supports includes CNC Manufacturing equipment, including mills, horizontal and vertical machining centres (HMCs and VMCs), lathes, Swiss lathes, laser cutters, plasma cutters, water jet cutters, and EDM cutters. Xometry manages the payments and transactions.

Guidelines for optimizing stakeholders configuration

- Offer the S.PSS to final user to improve the quality-of-life. **example 1**
- Offer the S.PSS to an entrepreneur to enable a business start-up or empower business. **examples 2**
- Optimise stakeholder partnership with vertical integration by combining all complementary components of one single DE type (i.e. DRE, the micro generator, the storage, the inverter, the wiring, etc.).
- Optimise stakeholder partnership with horizontal integration (by combining more than one DE type as a full package offer). **examples 3**
- Make the DE hardware manufacturer offers S.PSS either alone or in a joint venture with other stakeholders. **examples 4**

examples

1. Pick your own - USA

Fig. 3.62 top: Pick Your Own farms and activities[86]

Pick-your-own idea is for home or commercial users to pick their own fruits from the local farms near them. On the website PickYourOwn.org, there is a list of farms located all around the country who provides their products to be

86 Vezzoli, C., Garcia, B. and Kohtala, C. (2021) Design sustainability for all: the design of sustainable product-service system applied to distributed economics. S.l.: SPRINGER NATURE.

sold in this way. On the website, there is also a calendar of the harvesting time of different products. The home users or commercial users can pick fresh vegetables and fruits in these farms or in their own farms/gardens and produce canned/bottled/packed products using the kitchen/canning facilities that are by shared/community/commercial kitchens and canneries. The users can produce products for their own use as well as to sell. While some of the examples are more oriented towards home users, others are oriented towards commercial users. In most examples, they also provide information and education for production in their facilities. Some has licenses that enables users to produce for commercial use. They also function as hub for users to meet, collaborate and learn from each other. The two common payment methods are pay for period, per produced unit/each process or the combination of both.

2.1 Ethic bank - Banca etica

Fig. 3.63 Banca Etica main offer value[87]

87 Banca Etica (2022). Retrieved from: https://www.bancaetica.it/finanzaetica

The Italian Banca Popolare Etica aims to actualize the idea of a bank that is a meeting point for savers, who share the need of responsible and conscious administration of their own money. They also share the idea of a sustainable developing model, in which the creation and the distribution of richness are
founded on the values of the solidarity, the transparency and realisation of the common good. Banca Etica is aware of that the society's transformation goes through the productive systems transformation, in particular, it finances projects concerning social and environmental sustainability and gives the possibility to have access to credit for peo-

ple, who want to start a project in these areas.

2.2 Stratasys - 3d Printer Leasing

Fig. 3.64 Stratasys 3D printing kit, offered in leasing[88]

“Stratasys, Ltd. is a manufacturer of 3D printers and 3D production systems for office-based rapid prototyping and direct digital manufacturing solutions.” (Wiki) StrataSys offers leasing service of some models of their manufactured commercial 3D Printers in the USA only. They offer the lease of bundled 3D-printer packages. Besides the printer, the 3D Print Packs include start-up supplies, a support-removal system, and cleaning agent. Monthly lease packages are USD $290 for Print SE 3D Printing Pack that is priced USD $15,900 for sale and USD $380 for uPrint SE Plus 3D Printing Pack that is priced USD $20,900 for sale. The SE edition 3D Printers are designed for office use. (Nov. 17, 2011). For Mojo model, another office printer, the package costs $185/month. For the Dimension Elite 3D Printer (costs $31,900 to buy), monthly lease packages are available in the US at $560 and for the Dimension SST 1200es 3D Printer ($34,900), it starts at $610. (April 24, 2012) StrataSys also provides varies separate services such as system operation, in-house support, education, project implementation, consulting.

88 Vezzoli, C., Garcia, B. and Kohtala, C. (2021) Design sustainability for all: the design of sustainable product-service system applied to distributed economics. S.l.: SPRINGER NATURE.

3.1 Treatstock

“Treatstock is a 3D printing network, where 3D designers and print services can come together to produce 3D printed products for people all over the world. The site unites both a 3D printing marketplace and an online platform for 3D printing services, allowing distributed manufacturing.” (Wikipedia) Treatstock differs combines both a marketplace of 3D models and network of local 3D printers. They offer to the consumers the physical 3D printed product. Someone who wants to get a 3D model printed can receive every service they need from Treatstock. It is a distributed network of design and manufacturing combined.

3.2 Husk Power

Fig. 3.65 Biomass collection and system implementation[89]

The company provides energy solutions by installing biomass power plants and then wiring villages to deliver electricity. Husk Power design and installs the mini grids that can also be connected to the national grid. A partnership with local farmers is established to provide rice husk to power the plant. Household’s pre-pay a fixed monthly fee, around 2-3 euro, to light up two fluorescent lamps and

89 Vezzoli, C. et al. (2018) Designing Sustainable Energy for All. Cham: Springer International Publishing (Green Energy and Technology).

one mobile charging station (owned by the customer). The company retains ownership of the DG micro-generator, and it employs local agents for operation, maintenance and fee collection.

4.1 100KGarage

ShopBot is a company that designs, manufactures and distributes CNC routers for milling, drilling and cutting of wood, plastic, metals and other materials. Their CNC routers are commonly used in fablabs, schools and various community organizations. 100KGarages is an online platform created by ShopBot in collaboration with Ponko. At 100KGarages, people with designs or even just with an idea can connect to local fabbers (through an online matchmaking service) to get help with design and manufacturing to create things with 2D and 3D digital fabrication tools. In short, 100KGarages is a free resource that helps people find one another, learn from one another, and make their dreams for invention, creation and successful business come true. ShopBot offers various training services, live on-line training and on-site. It also offers a service for leasing their products.

4.2 Firstbuild

FirstBuild is a project where on-line and local community members can design products and help solve engineering challenges. There is an online platform in which the community can share their ideas and co-create home appliances. There is also a microfactory that provides advanced manufacturing techniques and rapid prototyping tools. Products can be made on a very small scale up to the thousands in this space which is open to public. “The FirstBuild Micro-factory is divided into four sections: an interactive space for brainstorming and product demonstration, a lab for prototyping, a shop to fabricate components, and a build floor where products are assembled.” (firstbuild.com)

Guidelines for delinking payment from hardware purchases and resource consumption

- Offer pay x period, i.e. the cost is daily/weekly/monthly/yearly fixed. **examples 1**
- Offer pay x time, i.e., the cost is fixed per minutes/seconds of access. **examples 2**
- Offer pay x use/satisfaction unit, i.e., the cost is fixed per product performance (e.g., km for a vehicle, washing cycles for washing machine). **example 3**
- Offer payment based on hybrid pay x period, pay x time, pay x use modalities. **example 4**
- Apply for additional financial support from public administrations/entities.

examples

1. Garden rent to retired people - Parco Nord garden Milan

Parco Nord proposes garden rent to retired people, homemakers and over 60 unemployed people. Meticulous care and cultivation, common spaces cleaning, watchfulness over gardens and an annual meeting for possible problems, activities, updating courses are requested to the assignees. The rental lease lasts 6 years, its renewable and the costs per year is fixed based on income. The service facilitates aggregation and socialization, stimulates self-confident and mutual help.

2.1 Makerbot - in-store 3d printing

MakerBot provided in-store 3D printing service. Users like designer/maker who wants to print a prototype or print the final product of their design, or even a user who does not know 3D modelling but wants to print a purchased or free 3D model they acquired, could go to a Makerbot store with a 3D file and get it printed. For this service, the 3D

printer model they used is MakerBot Replicator Desktop 3D Printers. The service included fixing the 3D file through a software, but they do not guarantee the problems that are originated from the design. Once the user went into a MakerBot store with a 3D file, the software calculated how long it would take to print and thus, how much the printing would cost. Then the user would be called once the printed objects were ready so that the users can pick them up. “Anything under thirty minutes was $10, while a two-hour print was $35, and a six-hour print was $100. Anything over six hours would require a specialized quote from MakerBot.”

2.2 Indigo – Azuri group

Indigo allows customers purchase a Solar Home System (SHS) for only 10 euro; composed by a 3-watt solar panel, battery, two LED lamps and one phone charge unit with cables.

Fig. 3.66 Solar panel installed on the roof of a rural settlement[90]

Customers then pay on a pay-as-you go system: buying 1 euro scratch card from local vendors to access electricity for a week inserting the code in their system battery. The power generated from these solar panels provides nearly eight hours of light each evening and supports mobile phone charging. Over the course of typically 18 months, the purchase of scratch cards allows the system to be paid off and the customer can choose to either unlock their Azuri system forever or upgrade to a larger model. Furthermore, considering customers may want more energy: for lights, to power a radio or TV or even power a sewing machine. Indigo allows customers to ride the Indigo Energy Escalator by

90 Vezzoli, C., Ceschin F., Osanjo, L., M’Rithaa, M.K., Diehl, J.C. (2018). Designing Sustainable Energies for All: Sustainable Product-Service System Design Applied to Distributed Renewable Energy. Switzerland: Springer.

which products are progressively upgraded over time to grow from simple systems to full home electrification.

3 South African township's solar-powered café

Fig. 3.67 Sample of solar-powered individual stations within the cafè[91]

The project offers a solar-powered connection centre and charging point, bringing low-cost access to IT services to the community of Alexandra. It is free for students and subsidized for adults. The only thing that users need to pay is the time they spend on the Internet or charging mobile phones based on three different offers: one internet access (in loco with provided EUP); one IT-service (one among photocopying/scanning/faxing/money transfer); one phone charging. Ownership of the connection centre and charging point (and of all the included Energy Using Products (EUP)) is retained by Solar Charge. Every centre will have a highly trained administrator to manage any problems that may arise. As additional service internet access is free for students, favouring education within the township.

91 Vezzoli, C. et al. (2018) Designing Sustainable Energy for All. Cham: Springer International Publishing (Green Energy and Technology).

4. Passa-tempo, the time bank of the University zone in Milan

The Time Bank of Milano Città Studi is part of the national system of Time Banks. These banks make economy by rewarding skills and knowledge, without using money. Anyone can sign up for the Time Bank, having as a requirement the willingness to "do" something in which you are competent. Who adheres to the BdT from their own willingness to make themselves useful on "call", in relation to their skills and competences. At the end of the year, an adjustment from an idea of the hours worked and received, but in case of non-homogeneity there are no sanctions or other procedures, the service is based solely on human relations. At the Porta Vittoria headquarters, courses, events, debates and exhibitions are organized to spend time with other people.

Optimise DE structure

- Offer stand-alone DE systems for homes or business sites (especially isolated sites).
- Offer local mini network connecting DE systems, to enable local production surpluses sharing or for enabling shared use of the DE hardware.
- Offer decentralized DE stations i.e. 3D printing service spot, charging spot, etc, for local communities. **examples 1**
- Offer decentralized Economy Systems to locally supply DE production throughout a mini network for homes and/or business sites. **examples 2**
- Offer DE system with connection to worldwide-network / main-grid, enabling homes, small business and communities the selling/purchasing of production or for enabling shared use of the DE hardware. **examples 3**

examples

1.1 Solar Transition – Kenya

Fig. 3.68 A family using a lamp provided by ISEG[92]

Ikisaya Solar Energy Group (ISEG) is a self-help group working in Kitui County, Kenya to provide energy services using solar energy to population in Ikisaya and surrounding areas. The main energy services provided using solar energy are lighting and phone charging. The services are designed for the rural poor population without electricity connection. The group has been operating from 2011 when it was registered. It was started by University of Oslo as a way of studying the best way to provide basic energy services to poor population in an affordable and sustainable way. They have been running both pay-as-you-go and rental services for solar lanterns at the centre at Ikisaya and through agents to spread the services to a wider area. Mutitu District of Kitui County is one of the underserved areas with very few electricity connections. The population in the rural areas mainly use kerosene for lighting. On the other hand, the area has very good solar irradiation making use of solar energy for lighting a very good option. Unfor-

92 Holsten, H.H. (2014) 'Solar energy provides electricity in remote areas'. University of Oslo. Available at: https://partner.sciencenorway.no/africa-forskningno-norway/solar-energy-provides-electricity-in-remote-areas/1397435

tunately, the high-quality solar gadgets are unaffordable for most of the poor people.

1.2 Shapeways, NY

Fig. 3.69 Shapeways sample 3D printed products and logo[93]

93 Shapeways (2022). Retrieved from: https://www.shapeways.com

Artists and designers who upload their digital models to Shapeways can have them printed and shipped to them. They can also set up shop and list their products for online sale. For online shopping, Shapeways print the products and send them to the shoppers. Shapeways provides professional grade printing with a wide range of material options. They also provide customization and software for modelling. They focus on developing these software and applications for integrating into their printing and shipping workflow. The objects are printed in the '3-D printing factory' in Queens, New York. The main offer is for the designers a complete package printing their designs on-demand by customers, shipping the printed products to them and managing the transaction between customers and designers. Designers do not need to pay for this service. They get a payment when a customer purchases a product of their design as after Shapeways deducts the cost of their services for shipping, printing, handling etc. Anyone can also just upload their files and get it printed and shipped by Shapeways paying for the 3D printing service according to the type and amount of the material used; type, quality and the duration of the printing; and shipping costs. These costs are calculated automatically by the software at the

website provided by Shapeways. Shapeways also provide a network of local 3D scanners that are integrated into their workflow, enabling customers to 3D scan and print things.

2.1 Hubs

Hubs is an online manufacturing service platform who offers a range of decentralised manufacturing services, including 3D printing, CNC machining, injection moulding and sheet metal fabrication services.
It operates a network of 3D printers with over 2,400 3D printing machines, and 1,600 milling and turning machines to supply decentralised manufacturing for users.
The company facilitates transactions between 3D printer and CNC machines owners (Hubs) and users who want to make 3D products. Machine owners can join the platform to offer manufacturing services while customers can get their models locally. Any owner who has an appropriate 3D printer or CNC machine can become a hub and offer their machines to others.

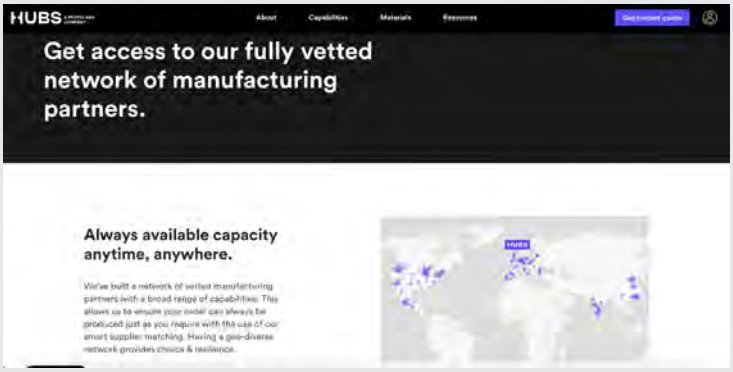


Fig. 3.70 Company's main value proposition[94]

94 Hubs (2022). Retrieved from https://www.hubs.com/partner-network/

2.2 Shared Solar

Shared Solar offers to houses and small businesses of off-grid rural villages a decentralized solar station connecting houses and small business through local mini-grid. Users pre-pay per time through scratch cards or even through mobile phones (without fee).

Fig. 3.71 Sample scheme of Shared Solar infrastructure and products within a village[95]

The solar station (micro generator and its accessories) is all owned by Shared Solar, as donation from the Millennium Village project (sponsoring the project). All energy using products are owned by the users. Added services are installation and in use services (i.e. maintenance, repairing, …) that are all in charge to Shared Solar. All stakeholders have access to real-time, contextual information. Customers can access their use and balance data, make payments, etc. using mobile phones. Operators have enhanced situational awareness and control, allowing them to manage their assets and operations effectively. Donors and governmental agencies can monitor performance using the same platforms. The generation and storage capacities are sized to match existing demand. As the demand grows over time, capacity is added through more solar panel or even other energy sources like wind, hydro, diesel etc. When the grid arrives, the local distribution network and management system can be utilized without modifications.

3.1 Pinshape, Vancouver, Canada

Pinshape offers 3D printing services. Designers can share and sell their models through the Pinshape online platform; final costumers select the product, which is then printed by the nearest 3D printer owner. The costumer receives

95 State of the Planet, Columbia Climate School (2013). Retrieved from: https://news.climate.columbia.edu/2013/05/15/the-microgrid-solution/

the product paying per printed unit. To offer the 3D printing service Pinshape involves 3D printer owners who are in charge to produce the products.
Designers are paid by Pinshape for each printed product. Pinshape also allows its users to review designs and share the settings they used to 3D print.

3.2 Linux

Fig. 3.72 Different potential applications of Linux operative system[96]

96 Vezzoli, C., Garcia, B. and Kohtala, C. (2021) Design sustainability for all: the design of sustainable product-service system applied to distributed economics. S.l.: SPRINGER NATURE.

Linux is a free and open-source operating system that is used in smartphones, personal computers, netbooks, supercomputers, servers, embedded devices, home appliances, cars etc. The underlying source code may be used, modified and distributed by anyone under the GNU General Public License, which requires that anyone who distributes software based on source code under this license, must make the originating source code (and any modifications) available to the recipient under the same terms. Founded in 2000, the Linux Foundation provides unparalleled support for open-source communities through financial and intellectual resources, infrastructure, services, events, and training. Working together, the Linux Foundation and its projects form the most ambitious and successful investment in the creation of shared technology.

3.3 Local Motors, vehicle manufacturing company

Local Motors (LM) is a motor vehicle manufacturing company focused on low-volume manufacturing of open-source motor vehicle designs using multiple micro-factories. Their products include the Rally Fighter automobile and Racer motorcycle, various electric bicycles, tricycles, children's ride-on toy cars, radio-controlled model cars and skateboards. They 3D print some components. Rally Fighters have used co-creation techniques, whereby products are designed cooperatively with end users, as part of its designing phase.

Fig. 3.73 Sample of co-created opensource car developed by local motors[97]

Their website is a community focusing on engine vehicle innovation. The content is co-created by the users of the community who discuss designing, engineering and building innovative engine vehicles. In the Local Motors website, designers, engineers, fabricators and enthusiasts can submit their ideas, receive feedback, and develop their designs. The Micro-factory is also open to anyone. Using the tools, parts, and the interactive online build manual, anyone who can construct their own vehicle in the Micro-factory with help from the Local Motors team. There are three micro-factories currently (Phoenix AZ, Las Vegas NV, Crys-

97 Vezzoli, C., Garcia, B. and Kohtala, C. (2021) Design sustainability for all: the design of sustainable product-service system applied to distributed economics. S.l.: SPRINGER NATURE.

tal City VA) but they are planning to increase the number to 100 Micro-factories around the globe in the next 10 years. The licensing and compensation are explained on the website as “When you publish your original work, you are the owner of that work under Creative Commons Attribution. When you submit your ideas or your own work to someone else’s original work and add value to it, you assign your commercial rights in your contribution to the owner of the original work, provided that you are compensated if the product is sold. Excluding this one important difference, your submission is still covered under the Creative Commons BY-NC-SA license. When we sell the product, we will compensate you according to your level of contribution to the product. When co-created products are sold, a percentage of revenue is reserved for all of the contributors”.

Chapter 4 (MSDS) Method for System Design for Sustainability

4.1 MSDS Method for System Design for Sustainability

The MSDS method aims to support and orient the entire process of system innovation development towards sustainable solutions. It is conceived for designers and companies, but is also appropriate for public institutions, NGOs and other types of organisations. It can be used by an individual designer, by a wider design team or by a multidisciplinary team facilitated by a designer. 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 scope of the MSDS method is to support design processes for the development of S.PSS, adaptable to specific design requirements and usable in existing design processes.
The users could be designer, design office, designer within a company or organisation.
All tools are open access and free to download at www.lens-international.org.

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

- Procedural stages: all the stages and related processes can be undertaken, or certain stages can be selected according to the specific requirements of the project.
- Tools to use: the method is accompanied by a series of tools. It is possible to select and deploy which of them to use during the design process according to the project need.
- Dimensions of sustainability: the method takes into consideration the various dimensions of sustainability (environmental, socio-ethical and economic). It is possible to choose to operate on environmental or socio-ethical, or on both (the economic dimension is anyhow taken into consideration).
- 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 specific aspects of the design project.

The basic structure of *MSDS* consists of four main stages:

- Strategic analysis
- Exploring opportunities
- System concept design
- System detailed design.

A further stage can be added, across the others, for 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.

MSDS method

Stage	Aim	Processes
Strategic analysis	To obtain the information necessary to facilitate the generation of sustainable system innovation ideas	• Analyze project proposers and outline the intervention context • Analyze the context of reference • Analyze the carrying structure of the system • **Analyze cases of sustainable best practice** • **Analyze sustainability of existing system and determine priorities for the design intervention in view of sustainability**
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** • **Outline a design-oriented sustainability scenario-visions/clusters/ideas**
System concept design	To develop one or more system concepts oriented towards sustainability	• Select clusters and single ideas • Develop system concepts • **Conduct environmental, socio-ethical and economic assessment and visualisation**
System detailed design (and Engineering)	To develop the most promising system concept into the detailed version necessary for its implementation	• Detailed system design • **Environmental, socio-ethical and economic check and visualisation**
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 overall qualities • **Draw up the documentation for communications of sustainability qualities**

Tab. 4.1 The stages of MSDS with their relative aims and processes. Sustainability-oriented processes are in bold.

4.2 Tools for System Design for Sustainability

This section describes several tools that may be used to support the various stages of the *Methodology for System Design for Sustainability* (MSDS). i.e. The design of Sustainable Product-Service System (S.PSS) eventually applied to Distributed Economies (DE)[98]. In general, the tools are created to support designers to achieve four specific objectives:

- To assess existing systems and define sustainability design priorities;
- To explore opportunities by generating sustainability-oriented ideas with a specific focus on S.PSS eventually applied to Distributed Economies;
- To visualize the proposed S.PSS and DE concept design;
- To detail and communicate the proposed S.PSS and DE concept design by highlighting environmental, social and economic benefits.

The total tools are presented in the sub-sections below:

- Innovation Diagram for S.PSS and DE

98 This is the one of the outcomes of the LeNSin project, creating, integrating, and updating tools produced by the project partners together with other existing tools and approaches linked to system design for sustainability. The tools described below have been used and tested during a set of pilot courses as part of the LeNSin project and in several studies with companies and industry experts. Experimentation in practical research projects and teaching is crucial for the LeNSin philosophy and will continue to be so in the future, in order to allow developed tools to be applied, adapted, and improved.

- Sustainability Design-Orienting (SDO) toolkit
- Sustainability Design-Orienting Scenarios (SDOS) on S.PSS and DE
- Stakeholders Motivation and Sustainability Table
- Concept Description Form for S.PSS and DE
- System Map for S.PSS and DE
- Interaction Table
- Stakeholders Interaction Storyboard
- Satisfaction Offering Diagram
- Animatic for S.PSS and DE
- Strategic Analysis Toolkit (SAT) for DE for Socio-Economic Ecosystems (SEE)
- Distributed Manufacturing (DM) Applied to PSS Design Toolkit
- E.DG - Estimator for Distributed energy Generation
- S.PSS + DG Innovation Map
- S.PSS + DG Design Framework & Cards

The aim of this section of the book is to help potential users to apply in practice the S.PSS and DE tools. Each tool is described using the following structure:

1. The aim;
2. The components of the tool (what it consists of);
3. Tool's integration into the MSDS design process;
4. How to use the tool in the design process;
5. Availability and resources required.

4.2.1 Innovation Diagram for S.PSS and DE

Fig. 4.1 Overview of the Innovation Diagram for S.PSS and DE

Aims

The objective of the *Innovation Diagram for S.PSS and DE* (Fig. 4.1) is to a) position and characterize existing offers; b) map competitors strategic positioning; c) select promising system sustainability ideas and help achieve a new concepts profiling.

What it consists of

The diagram consists of:

- *Polarity diagram concept profile*
- *Digital post-it*
- *Repository of labels*

Integration into the MSDS design process

The Innovation Diagram for S.PSS and DE is used at various stages of the design process (Fig. 4.2).

- In **Analysis of the project promoters and the reference context** it can be used to analyze the current offer and the related competitors' offers to orientate promising ideas.
- In **Visions, clusters and ideas selection and System**

concept development it can used to select, map, and cluster most promising ideas and create the profile and S.PSS concept.

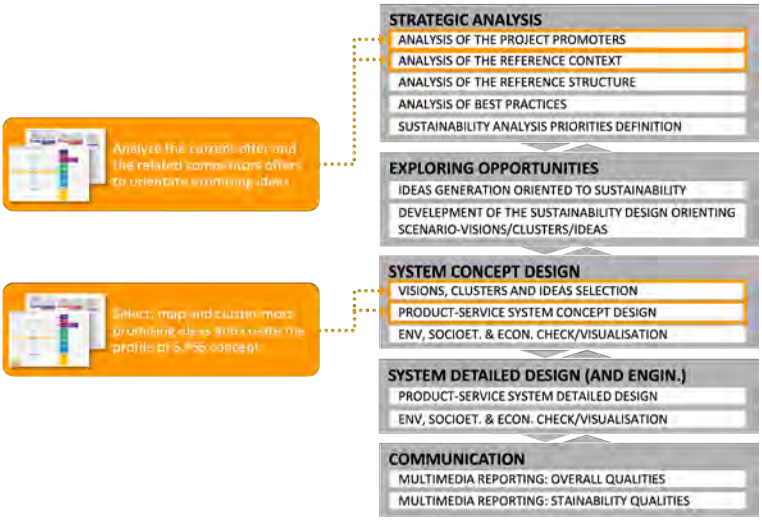


Fig. 4.2 Integrating Innovation Diagram for S.PSS and DE into MSDS design process

How to use the *Innovation Diagram for S.PSS and DE*

To begin, download and open the tool and move to the "…_existing offer" slide. Work in the "existing offer" slide to position an existing offer (Fig. 4.3). From the repository slides, select the company/organisation icon (1) and write the company/organisation name in the free space on the label. Successively, paste the label in the diagram and in the characterisation table on the right (2)

The second step is to characterize the existing offer by specifying all the following (Fig. 4.4):

- **Type of provider (1)**. Select the company/organization icon and choose one of the DE types (characterisation icons) to substitute the general one. Place in the provider section and write the company/organization name in the free space on the label.
- **Type of customer (2)**. Select customer/s (B2B – B2C) icon/s and choose one of the DE types (characterisation icons) to substitute the general one. Place in the

customer section and write customer/s name in the free space on the label.

- **Type of PSS (3)**. Select the S.PSS type of the offer (if any): PRODUCT-ORIENTED, USE-ORIENTED, RESULT-ORIENTED and place it in the S.PSS type section. Remember, that not all offers are already S.PSS.
- **Products/ownership (4)**. Select the product icon the company offers and paste in the products section. Select who retains the product OWNERSHIP (provider or customer) and place the label in the provider/customer label.
- **Services/providers (5)**. Select the service icon the company offers and paste in the service section. Select who PROVIDES the service and place the label in the provider label.
- **What is paid (6)**. Select the icon describing what is paid by the customer/s and place the label in the payment section.
- **Offer configuration (7)**. Select the DE type icon of the offer and paste it in the DE type space. Select its structure icon and place it in the nearby space.

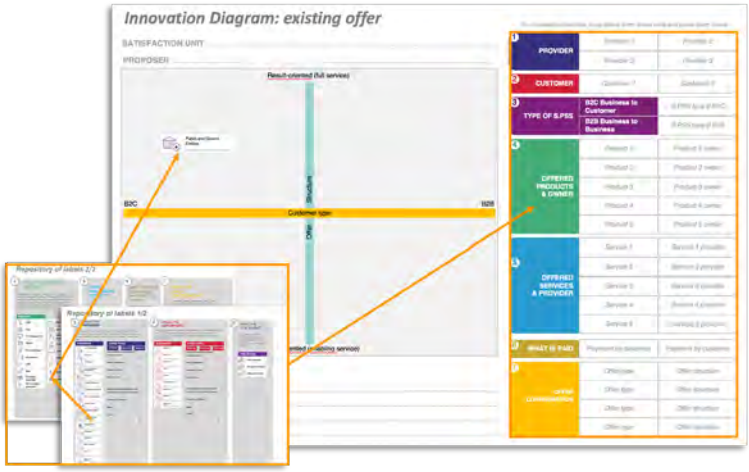


Fig. 4.3 The existing offer slide of the Innovation Diagram for S.PSS and DE

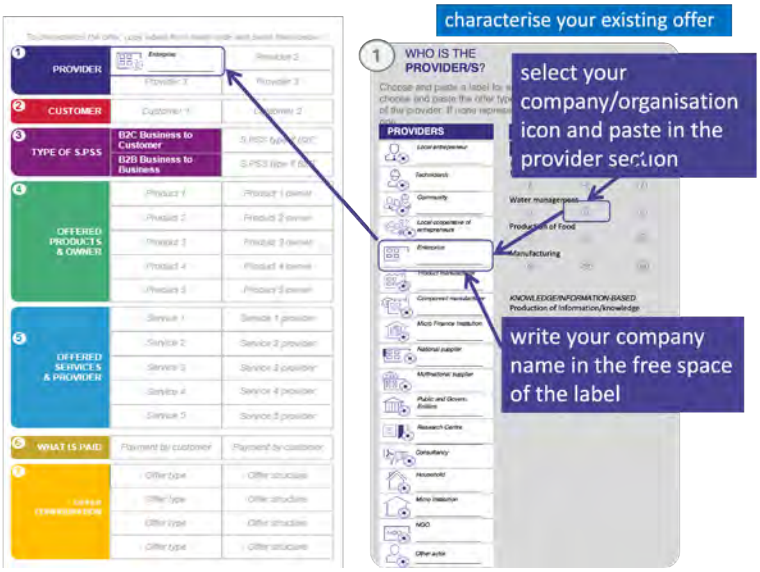


Fig. 4.4 Elements to characterize the existing offer in relation to the type of provider

Fig. 4.4 exemplifies the process for the realization of providers' icons and labels. With the same logic, the process can be applied to customers, type of S.PSS, offered products and owners, offered service and providers, payment and offer configuration.

The same process made to characterize the existing offer, could be done in relation to competitors, by moving to the "..._Competitors" slide.

The Innovation Diagram for S.PSS and DE is also meant to be used in combination with other tools. Indeed, in the "Concept" section, it can be used to select and position promising ideas designed with idea boards (SDO toolkit)[99], within the "..._Concept" slide (Fig. 4.5) (following SDO color code).

99 Check the tool in chapter 4.2.2

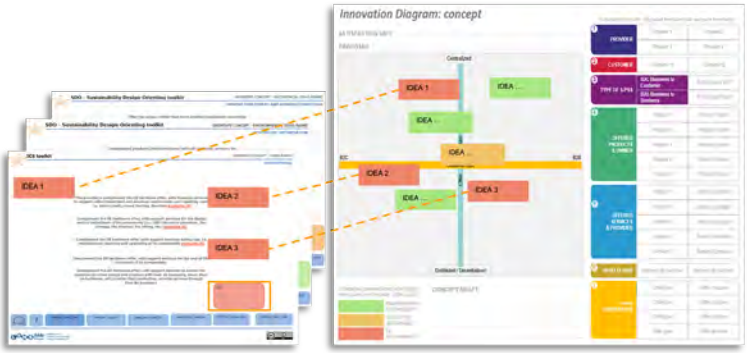


Fig. 4.5 Concept slide of Innovation Diagram for S.PSS and DE with the SDO idea boards

Now it is time to generate new ideas spotting the areas that are left empty (Fig. 4.6) (1). Identify and cluster those ideas that can be combined to draft the system concept (2). Write a text (max 200 characters) drafting the preliminary system concept (3).

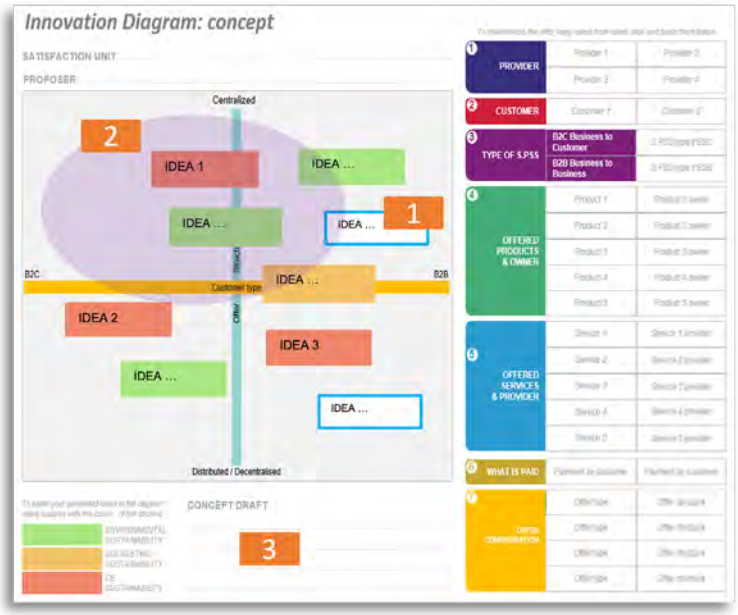


Fig. 4.6 Idea generation, idea clustering, and system concept drafting

Finally, profile the S.PSS&DE draft concept by copying and pasting characterizing icons of the emerging S.PSS&DE concept (Fig. 4.7).

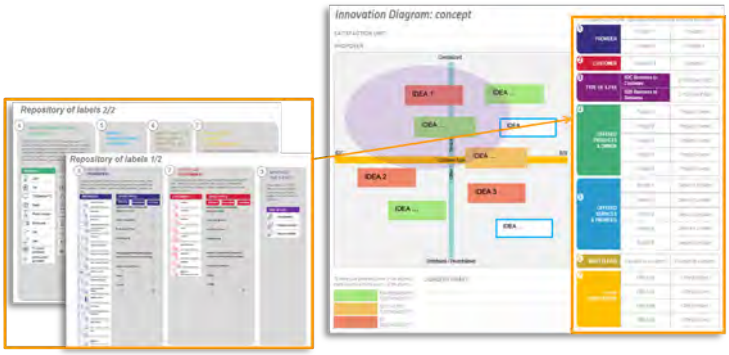


Fig. 4.7 Profiling S.PSS and DE draft concept

Availability and requested resources

The Innovation Diagram for S.PSS and DE is an open access tool that can be downloaded for free from www.lens-international.org, 'Tools' section. A computer and a PowerPoint reader are needed to access the tool. This tool requires at least:

- 15 minutes to position and characterize existing offer,
- 30 minutes to position and characterize competitors,
- 45 minutes to select promising ideas, generate new ones, cluster them and identify/describe/profile a draft concept.

Similar tool

This chapter has presented the tool - Innovation Diagram for S.PSS and DE. Another type-specific tool - Innovation Diagram for S.PSS & DG (Distributed energy Generation) have been developed to support the specific S.PSS & DE type, i.e. existing S.PSS & DG offers position and characterization; Mapping S.PSS & DG competitors strategic positioning and select promising S.PSS & DG system sustainability ideas and help achieve a new S.PSS & DG concepts profiling. Innovation Diagram for S.PSS & DG could be found in the book "Designing Sustainable Energy for All" (Vezzoli et al., 2018) chapter 7.2.8.

4.2.2 Sustainability Design-Orienting (SDO) toolkit

Aims

The objective of this tool is to orientate system design process towards S.PSS solutions: environmental, socio ethical and S.PSS applied to Distributed economies.

This happens thanks to the different functions of the tool, which is made to support designers in: qualitatively analysing the existing system unsustainability and setting sustainability priorities; using sustainable idea generation boards with design-orienting guidelines and related best practices. checking and visualising the potential improvements in relation to an existing reference system.

It is essentially a tool that can support several design processes, 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 specific aims of the tool are here explained in detail:

- To analyse qualitatively the unsustainability of the existing (reference) system and then to define the design priorities for both environmental and socio-ethical sustainability dimensions (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 a set of checklists to analyse the existing system (SDO section: 'Analyse the existing system & Set Priorities')
- To stimulate the generation of ideas for potentially sustainable systems. This is done by using a set of idea generation boards with design strategies, guidelines and best practices oriented towards sustainability (SDO section: 'Orientate Concept')
- To assess potential improvements, or any worsening, associated with both the environmental and socio-ethical 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').

What it consists of

The SDO is based on a spreadsheet file that integrates different tools and allow to navigate through them. In particular, for both the environmental and the socio-ethical dimensions of sustainability, the toolkit includes:

- Six boards (one per each strategy) with checklists for the existing system qualitative sustainability analysis and the successive prioritization of sustainability strategies.
- Six boards (one per each strategy) to generate sustainability-focused system ideas with the support of best practices.
- Six boards (one per each strategy) with checklists to assess the sustainability improvement/worsening of developed system concept/s.
- A single summary board to visualize the sustainability improvement/worsening of developed system concept/s, as well as report.

Integration in MSDS design process

A. prioritises sustainability strategies/guidelines (tool: checklist/existing system)
B. sustainability-focused idea generation (tool: idea boards + guidelines + examples)
C. sustainability improvement check/visualisation (tool: checklist/concept; radars)

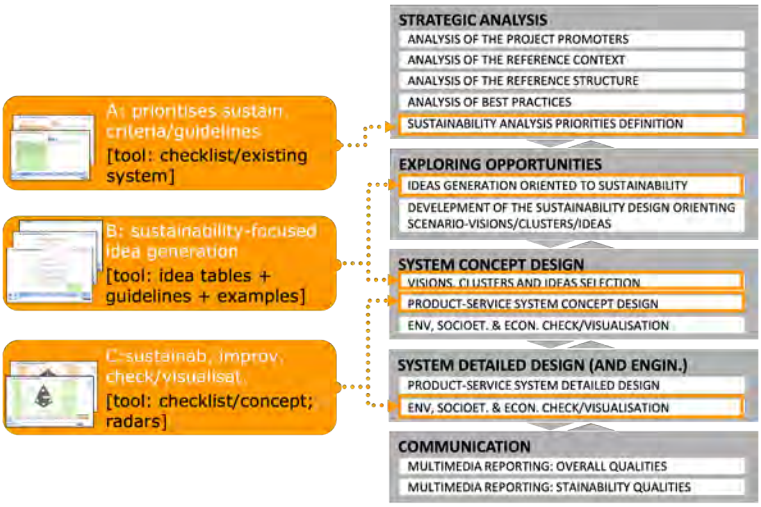


Fig. 4.8 Integrating the Sustainability Design-Orienting (SDO) toolkit into MSDS design process

How to use the *SDO toolkit*

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

- *Start up*

Firstly, login into www.lens-international.org and download the SDO toolkit from the 'Tools' section. When opening the downloaded file, the homepage interface is visualized. As a preliminary step, click on the 'Project record' button and fill-in your project data (Fig. 4.9).

Fig. 4.9 The SDO toolkit's first page after opening

Below we describe how to use the toolkit in the following processes:

- A: existing system qualitative sustainability analysis + prioritisation of sustainability strategies.
- B: generate sustainability-focused idea with the support of existing best practices.
- C: check/visualise sustainability improvement/worsening of developed concept/s.

A: existing system qualitative sustainability analysis + prioritisation of sustainability strategies

Select the sustainability dimension to work on and click, e.g. environment.(1) (Fig. 4.10). Successively, start from. "analyze & set priorities" (2)

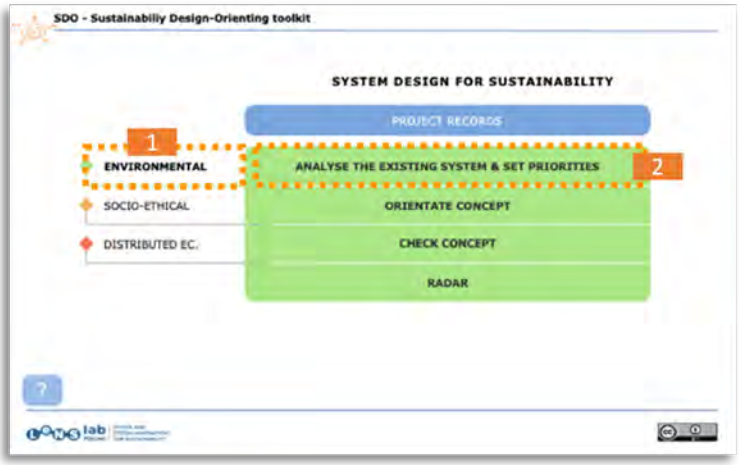


Fig. 4.10 Selection of the sustainability dimension to work on (1) and start from the analysis of the existing system (2)

Select the strategy one by one to work on (3), e.g., system life optimisation (Fig. 4.11), read one by one the evaluation checklist (4) and give respective answers (5), in order to evaluate the existing system. When the evaluation is made for all the checklist, low-medium-high or very high priorities can be defined using the central column (6).

Fig. 4.11 Checklist for existing system analysis and strategies priorities setting (SDO toolkit - environmental)

B: generate sustainability-focused idea with the support of existing best practices

The objective of S.PSS Idea Boards (Fig. 4.12) is to support designers in orientating system idea.
To do so, a series of design guidelines can be used for each strategy, as a support and stimulus. Within the *SDO*, in the menu on the left, select a sustainability dimension (i.e., environmental, socio-ethical, and distributed economy) and click on 'Orientate Concept'.

Fig. 4.12 Sustainable Idea Boards (SDO toolkit - environmental)

At the lower menu, six design strategies appear in six blue boxes where it is possible to see the priorities assigned during the analysis of the existing system (only for the environmental and socio-ethical dimensions), with a set of corresponding guidelines and links to some inspirational real case examples. These guidelines stimulate the generation of ideas, which can be noted on the digital 'post-its' to be found at the sides of the screen. Obviously, as mentioned, the idea generation session must give more attention/time to the strategies with the highest priorities. For example, if *System life optimisation* is a high priority, the designer should start with the idea board referring to this strategy, getting inspiration from the related guidelines and examples. At the same time, if *Reduce transportation/distribution* has a low priority, less attention will be given to it (or even no attention if it has 'No' priority).

In practice (Fig. 4.13), select one by one the idea boards (one for each strategy) (1). Then, read the guidelines (a set for each strategy) (2) and to facilitate ideas generation, have a look to the examples related to guidelines (3). You can see and read more info on the case related to the specific guideline (4). Use the guidelines as support to generate/design Environmentally Sustainable S.PSS based ideas/solutions (5).

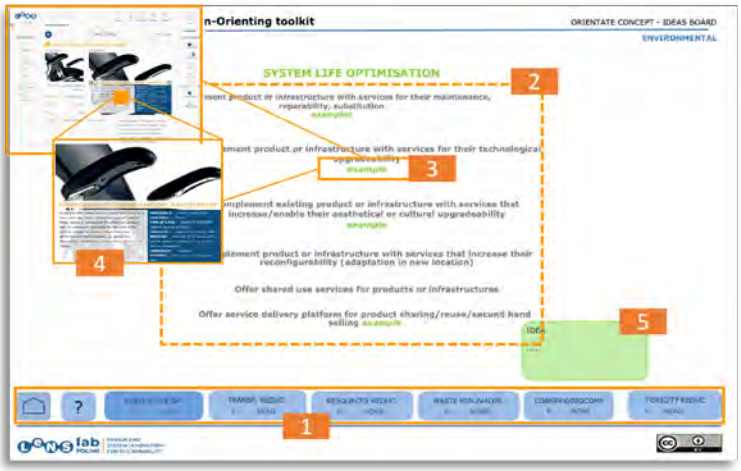


Fig. 4.13 Idea orientation and generation using the Sustainable Idea Boards

C: check/visualise sustainability improvement/worsening of developed concept/s.

The aim is to analyse the system concept to identify its potential improvements over the existing system. Select a sustainability dimension e.g., environment (Fig. 4.14) (1) and click on 'Check Concept' (2). In reference to the provided checklist for each strategy (Fig. 4.15), write a qualitative sustainability improvement of concept compared with the existing system through the specific text box on the right side (3). For each strategy it is possible to select (4): radical improvement (++), incremental improvement (+), no significant change (=), or worse (-). The selected improvement rate is then automatically visible on each strategy button (5). By opening the 'Radars' section (Fig. 4.16) on the home menu and selecting the desired sustainability dimension e.g., environmental radar (1), it is possible to visualise the potential improvements of the concept in relation to the initial system, for each strategy. Write the abbreviation of existing system priorities (for each strategy) (2), then visualise the concept improvements for each related strategy (3). Finally, recap the improvements in the text boxes (4).

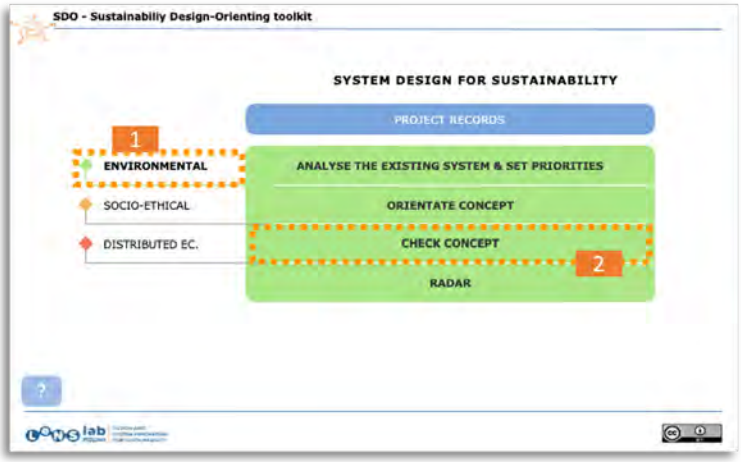


Fig. 4.14 Selection of the sustainability dimension to work on (1) and start to check concept (2)

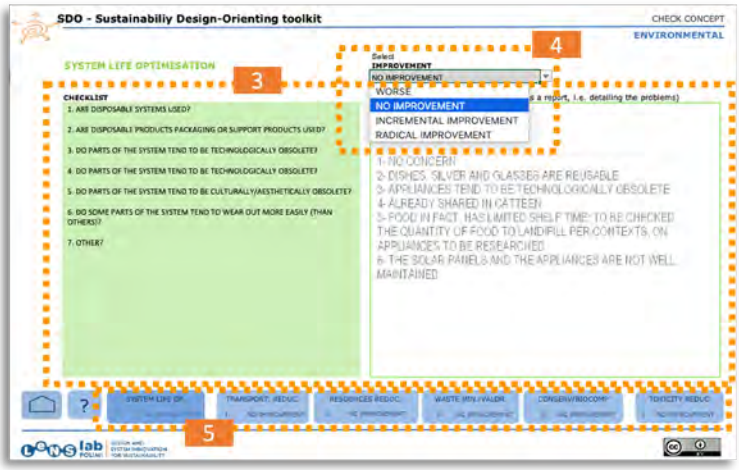


Fig. 4.15 Checklist for the system sustainability improvement evaluation (SDO toolkit - environmental)

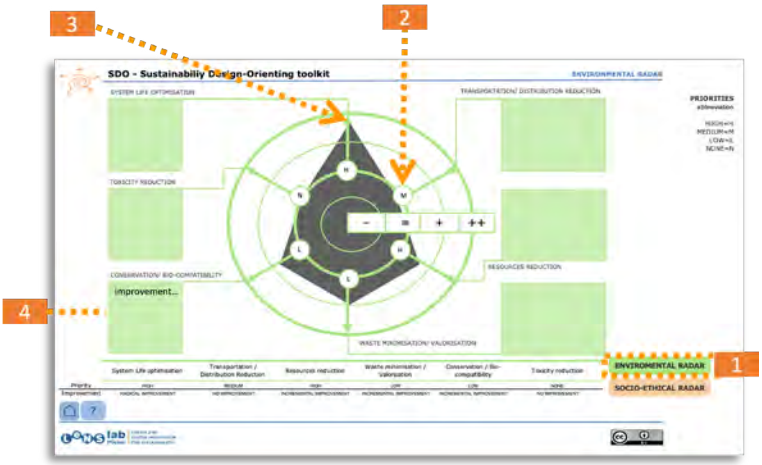


Fig. 4.16 Radar diagram (SDO toolkit - environmental)

Availability and requested resources

The SDO toolkit is open access and can be downloaded for free from www.lens-international.org ("Tools" section). A spreadsheet reader is needed to use the tool. As regards timing, the sustainability evaluation activity can take from 45 to 90 minutes; Idea Boards are required from 60 to 180 to complete. The check of progress can take from 30 to 60 minutes.

Similar tool
This chapter has presented the SDO toolkit, within which the Sustainable Idea Boards could support S.PSS & DE Idea orientation and generation. Another type-specific tool - Sustainable Energy for All Idea Tables and Cards have been developed to support the specific S.PSS & DE type i.e. generate ideas for S.PSS applied to DG solutions, it is based on six idea tables with guidelines. 'Sustainable Energy for All Idea Tables and Cards' could be found in the book "Designing Sustainable Energy for All" (Vezzoli et al., 2018) chapter 7.2.3.

4.2.3 Sustainability Design-Orienting Scenarios (SDOS) on S.PSS and DE

Aims
The objective of *Sustainability Design-Orienting Scenarios (SDOS) on S.PSS and DE* (Fig. 4.17) is to orient the design process towards sustainable system solutions by using immersive and inspiring scenario videos to stimulate the generation of *S.PSS&DE-based* ideas for all.

What it consists of
The Sustainability Design-Orienting Scenarios (SDOS) on S.PSS and DE consist of four visions designed by a polarity diagram described by:

- Four videos, one per each vision
- Three sub-videos presenting options of:
    - Offer/payment
    - System configuration
    - Sustainability.

Fig. 4.17 SDOS on S.PSS and DE tool

Integration into the MSDS design process

The *SDOS on S.PSS and DE* is used in **Ideas generation oriented to sustainability** to stimulate the generation of *S.PSS&DE* ideas for all (Fig. 4.18).

Fig. 4.18 Integrating SDOS on S.PSS and DE into the MSDS process

How to use the *SDOS on S.PSS and DE*

The tool is used in two simple steps:

Firstly, after downloading the *SDOS on S.PSS and DE* from

www.lens-international.org, open it and play the four videos of the four visions, to get design inputs through sample stories (Fig. 4.19).

Fig. 4.19 The menu page of the SDOS on S.PSS and DE tool with the links to the 4 vision videos

Secondly, play the 3 sub-videos, to open from sample stories linked to all options related to:

- Offer/payment
- System configuration
- Sustainability (Fig. 4.20)

Fig. 4.20 SDOS on S.PSS and DE tool links to the three sub-videos visualizing offer/payment, system configuration, and sustainability

Availability and requested resources

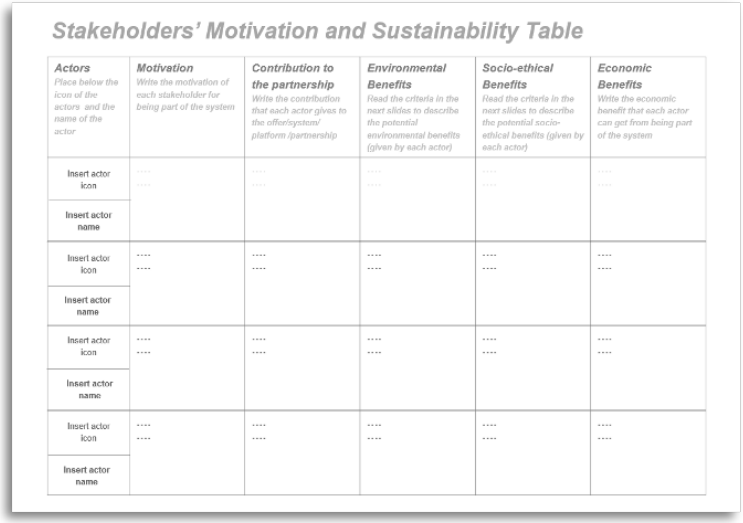
The *SDOS on S.PSS and DE* tool is an open-source tool that can be downloaded for free from www.lens-international.org, 'Tools' section. A computer, a PDF reader, and Internet

connection are required to access the tool.
The tool may be used by a single designer, though the support of a multi-disciplinary team is preferable.
It requires at least 15 min to explore and get inspired by the proposed visions.

4.2.4 Stakeholders Motivation and Sustainability Table

Aims

The objective of the Stakeholders Motivation and Sustainability Table (Fig. 4.21) is to visualize (identify) the motivations and benefits those actors have in being involved in the system together with environmental, socio-ethical and economic benefits.



Stakeholders' Motivation and Sustainability Table

Actors Place below the icon of the actors and the name of the actor	Motivation Write the motivation of each stakeholder for being part of the system	Contribution to the partnership Write the contribution that each actor gives to the offer/system/ platform /partnership	Environmental Benefits Read the criteria in the next slides to describe the potential environmental benefits (given by each actor)	Socio-ethical Benefits Read the criteria in the next slides to describe the potential socio-ethical benefits (given by each actor)	Economic Benefits Write the economic benefit that each actor can get from being part of the system
Insert actor icon Insert actor name	---- ----	---- ----	---- ----	---- ----	---- ----
Insert actor icon Insert actor name	---- ----	---- ----	---- ----	---- ----	---- ----
Insert actor icon Insert actor name	---- ----	---- ----	---- ----	---- ----	---- ----
Insert actor icon Insert actor name	---- ----	---- ----	---- ----	---- ----	---- ----

Fig. 4.21 Stakeholders Motivation and Sustainability Table

What it consists of

The tool consists of a table in which the header row is pre-filled with five voices: motivation; contribution to the partnership; environmental benefits; socio-ethical benefits; economic benefits. The header column has space for different actors of the system.

Integration into the MSDS design process

The Stakeholders Motivation and Sustainability Table can be used in two different moments of the MSDS Method (Fig. 4.22). First, during the system concept design phase and within the **PSS concept Design** and the **final sustainability check and visualization** (environmental, socio-ethical and economic): To visualize (identify) the motivation that actors have in being involved in the system and sustainable benefits. The tool can also be used during the system detailed design and engineering: To visualize (detail) the motivation that actors have in being involved in the system and sustainable benefits.

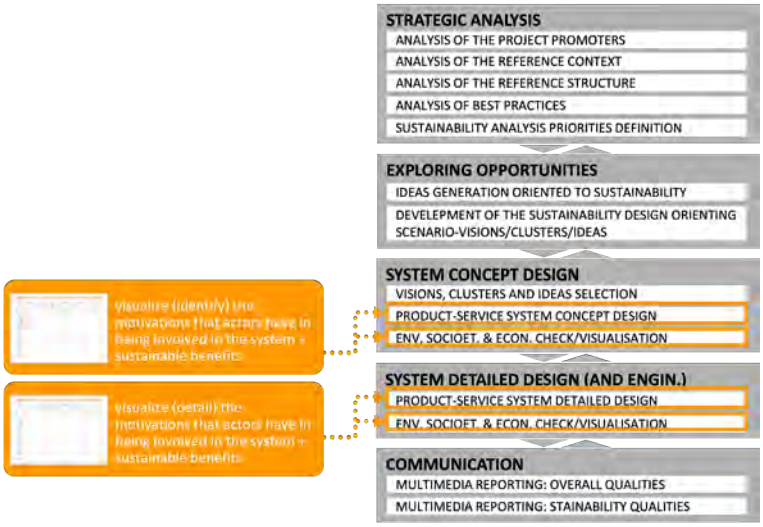


Fig. 4.22 Integration of the Stakeholders Motivation and Sustainability Table within the MSDS method

How to use *Stakeholders Motivation and Sustainability Table*

After downloading the Stakeholders Motivation and Sustainability Table from www.lens-international.org in the "Tools" section, the is following steps must be undertaken to use the tool:

- Identification and positioning of actors in the header column (Fig. 4.23):
- Go to the "..._stakeholder icons" page in the tool, select

a structure icon in the left box (e.g., Providers), then choose characterization icon from the right box (e.g., Energy Generation) to substitute the general one. Finally, drag and drop the icon into the table (Fig. 4.24).

- From the stakeholder icons repository, select a structure icon and then a characterization icon to substitute the general one, then drag and drop it in the table
- Write for each actor its motivation to be in the system (Fig. 4.25)
- Write the contribution of each actor to the platform (Fig. 4.26)
- Write the potential environmental benefits they can promote within the system (Fig. 4.27)
- Write the potential socio-ethical benefits they can promote within the system (Fig. 4.28)
- Write the potential economic benefits they can promote within the system (Fig. 4.29)

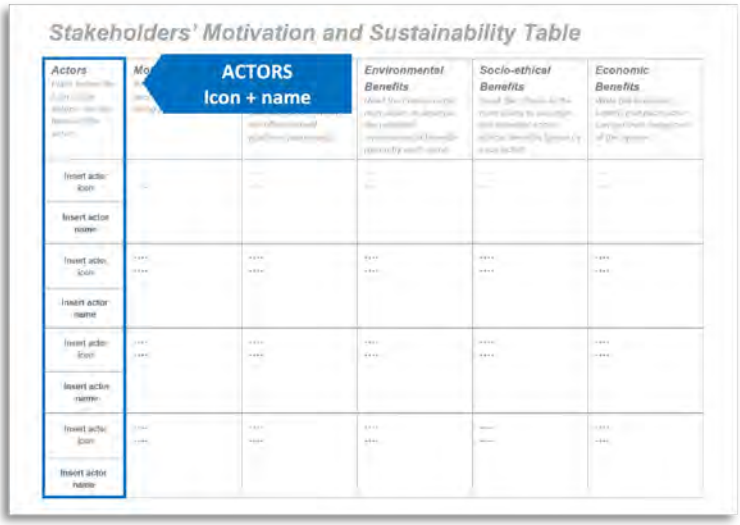


Fig. 4.23 Stakeholders Motivation and Sustainability Table: actors' column

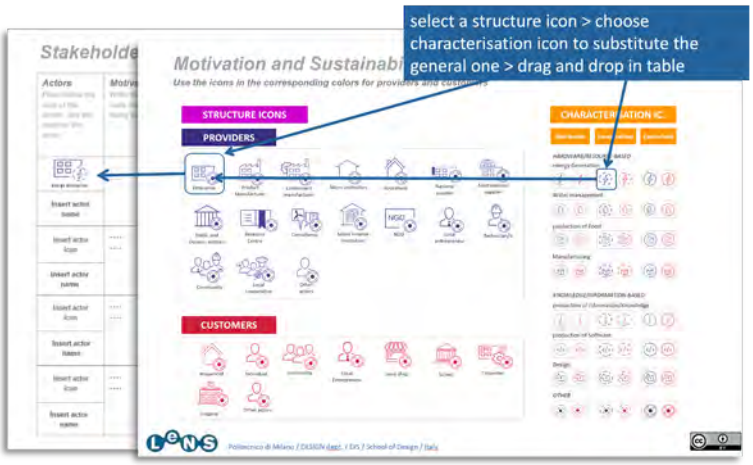


Fig. 4.24 Selection and combination process of actors' icons

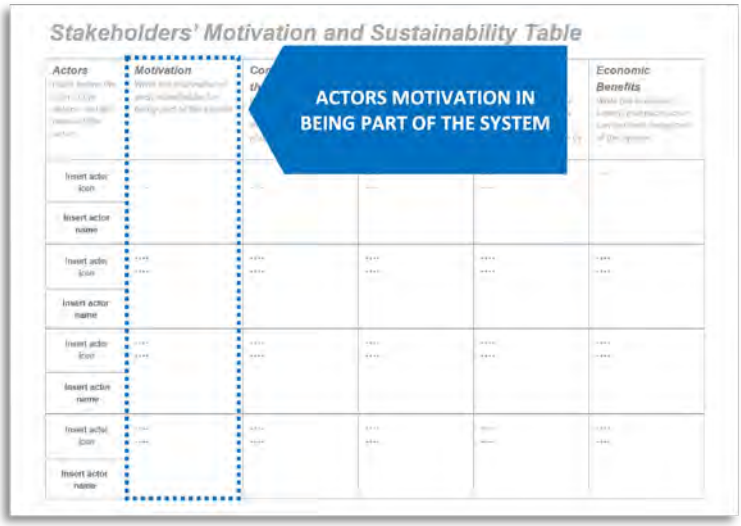


Fig. 4.25 Actors' motivation (Stakeholders Motivation and Sustainability Table)

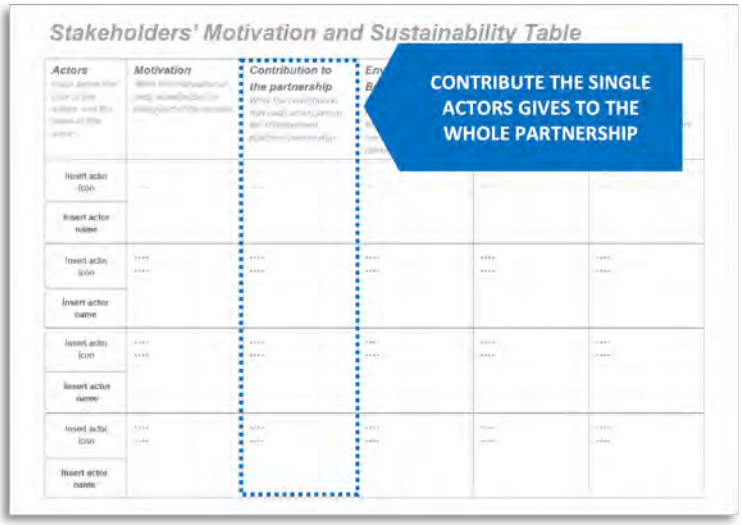


Fig. 4.26 Actors' contribution to the partnership (Stakeholders Motivation and Sustainability Table)

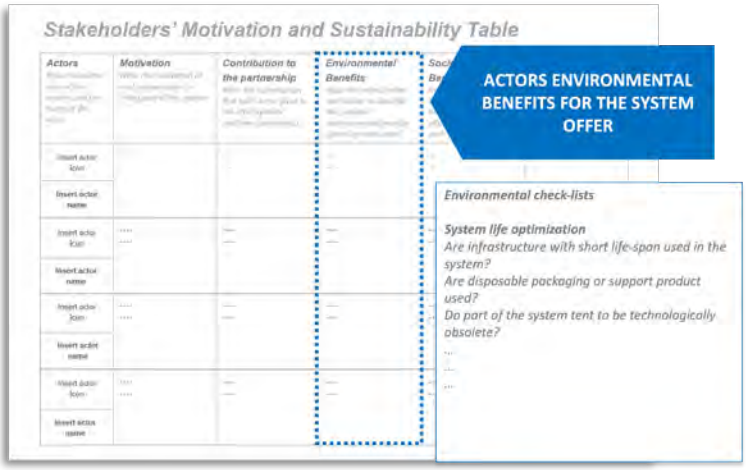


Fig. 4.27 Actors' environmental benefits for the system offer (Stakeholders Motivation and Sustainability Table)

Fig. 4.28 Actors' socio-ethical benefits for the system offer (Stakeholders Motivation and Sustainability Table)

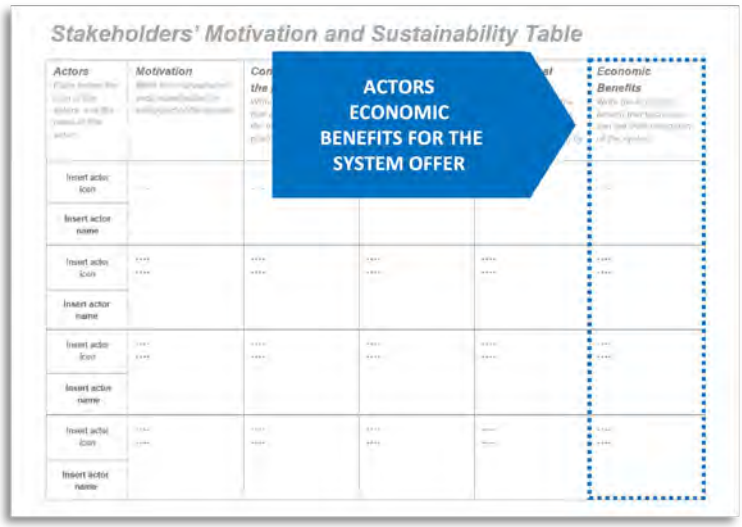


Fig. 4.29 Actors' economic benefits for the system offer (Stakeholders Motivation and Sustainability Table)

Availability and requested resources

Stakeholders Motivation and Sustainability Table is an open-source tool that can be downloaded for free from www.lens-international.org, 'Tools' section. A computer, a PowerPoint reader are required to access the tool.
The table requires at least 45 minutes to be completed.

4.2.5 Concept Description Form for S.PSS and DE

Aims

The objective of the *Concept Description Form for S.PSS and DE* (Fig. 4.30) is to finalize description and characterization of a new concept of S.PSS (applied to DE).

What it consists of

The tool consists of a sum-up of the concept with:

- Concept title
- Satisfaction unit
- Concept description
- Concept profiling (i.e. Provider, Customer, Type of S.PSS, Offered Products & Owner, Offered Services & Provider, what is paid, Offer configuration.)

Fig. 4.30 Concept Description Form for S.PSS and DE

Integration into the MSDS design process

The Concept Description Form for S.PSS and DE is used within the **Product-Service System concept design** phase to describe and profile the designed S.PSS and DE concept (Fig. 4.31)

Fig. 4.31 Integrating Concept Description Form for S.PSS and DE into the MSDS method

How to use *Concept Description Form for S.PSS and DE*

After downloading the Concept Description Form for S.PSS and DE from www.lens-international.org in the "Tools" section (Fig. 4.32), the title and the description of the S.PSS concept must be written in the respective boxes (1). Indicate the unit of satisfaction of the concept (2) and finally characterize it with information in all the fields (3)

Fig. 4.32 The order to fill all components of the Concept Description Form for S.PSS and DE

Availability and requested resources

Concept Description Form for S.PSS and DE is an open access tool that can be downloaded for free from www.lens-international.org, 'Tools' section. A computer and a PowerPoint reader are required to use the tool.

The Concept Description Form for S.PSS and DE requires 15 to 30 minutes to be completed.

4.2.6 System Map for S.PSS and DE

Aims

The purpose of the System Map for S.PSS and DE (eventually applied to DE (Fig. 4.33) is to support (co-designing), visualization and configuration of the system structure, indicating the actors involved and their interactions in the system. Providing additional support to its users in defining DE configuration.

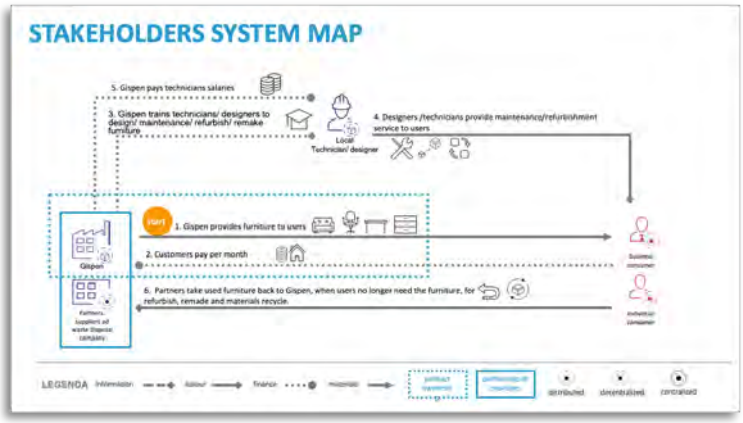


Fig. 4.33 Overview of the System Map for S.PSS and DE

What it consists of

The System Map for S.PSS and DE is a graphical representation of:

- stakeholders involved;
- flows/interactions: physical, financial, informational, and labor performance.

Integration into the MSDS design process

The System Map for S.PSS and DE is used at various stages of the design process (Fig. 4.34):

- **Analysis of the Reference Structure**, can be used to visualize stakeholders' interactions within the existing (reference) offer.
- **Product-Service System Concept Design**, can be used to visualize stakeholders' interactions within the concept.
- **Product-Service System detailed design**, can be used to further detail and visualize stakeholders' interactions within the detailed concept.

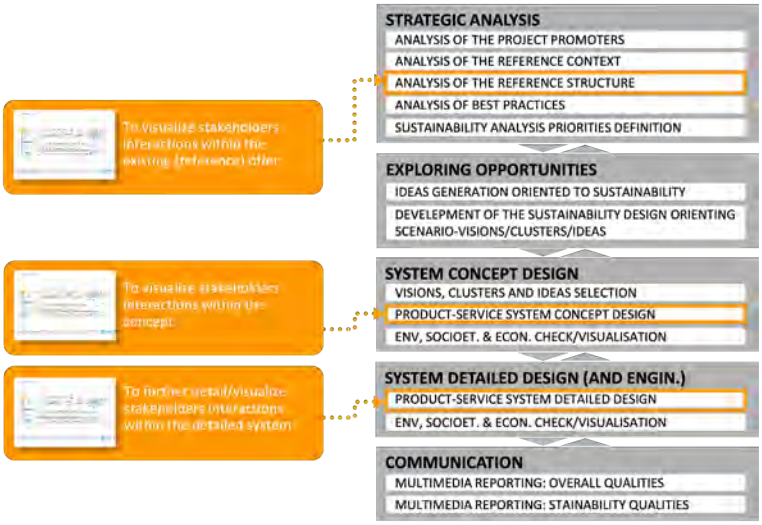


Fig. 4.34 System Map for S.PSS and DE integration into the MSDS design process

How to use the *System Map for S.PSS and DE*

The System Map for S.PSS and DE enables comprehensive visualization of the system structure. The first step is to set boundaries (Fig. 4.35), including offer boundary (1) where the main stakeholders have to be positioned, and set a system boundary for the secondary ones (2). To

characterize the stakeholders (Fig. 4.36), structure icons (3) must be combined with characterization icons (4) and descriptive text (5). Another element that distinguishes stakeholders is the color (Fig. 4.37): dark violet is used for providers (6) while magenta is used for customers (7). All the icons are available in the "...stakeholder icons" page of the tool (Fig. 4.38), from which they can be combined and drag-dropped into the map board. Later, define interaction flows (Fig. 4.39) using arrows and descriptions. Interaction flows (Fig. 4.40) can be material flow (8), information flow (9), financial flow (10), and labor flow (11). Remember, that the reading order is important, thus note the numbering of interaction flows (Fig. 4.41). To create interaction flows, move to "..._flows" page of the tool (Fig. 4.42), drag and drop them into system map. Then the same process to the interaction characterization icons (Fig. 4.43). Finally, use dashed squares to indicate ownership of a system or a product (Fig. 4.44) and squares around actors to indicate partnership (Fig. 4.46). Both dashed squares and squares are available in the "..._icons" page with the same way to use (Fig. 4.45, Fig. 4.47).

Fig. 4.35 Setting boundaries and stakeholders (System Map for S.PSS and DE)

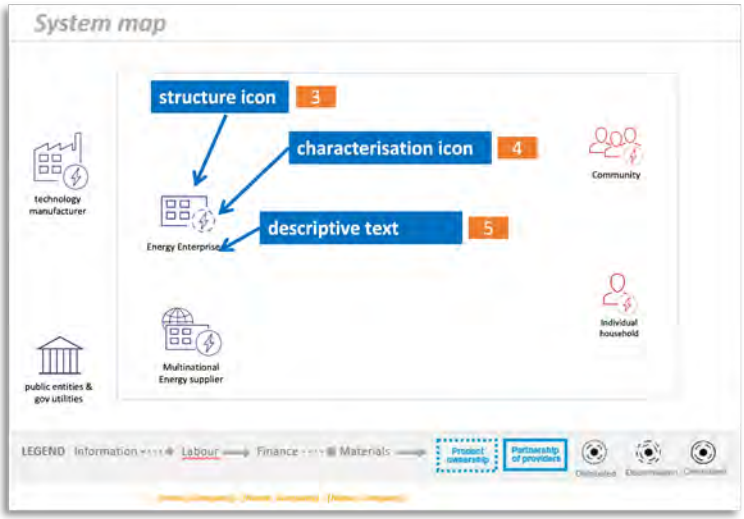


Fig. 4.36 Characterizing stakeholders (System Map for S.PSS and DE)

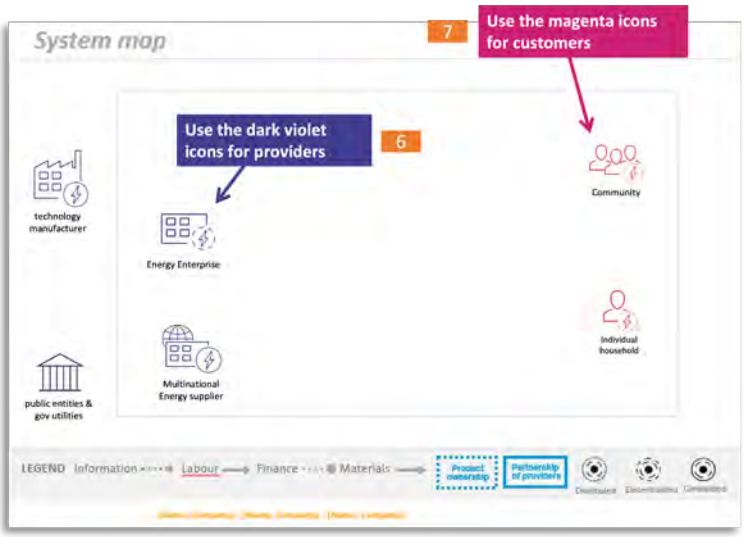


Fig. 4.37 Distinguishing stakeholders by colors (System Map for S.PSS and DE)

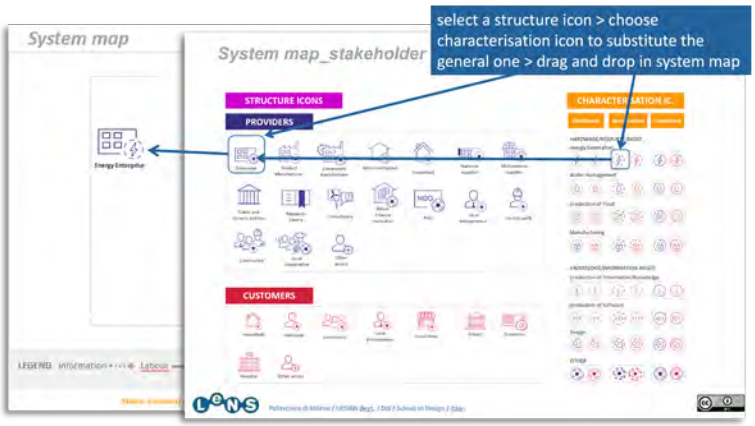


Fig. 4.38 Stakeholders icons' repository of the System Map for S.PSS and DE

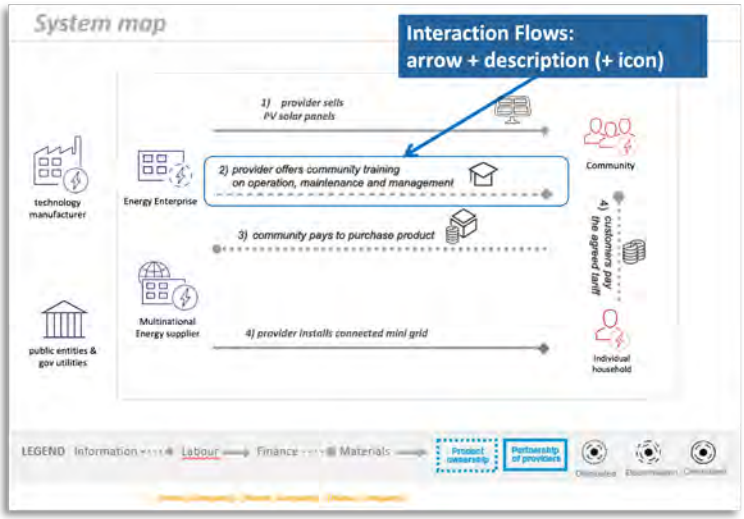


Fig. 4.39 Defining interaction flows of the System Map for S.PSS and DE

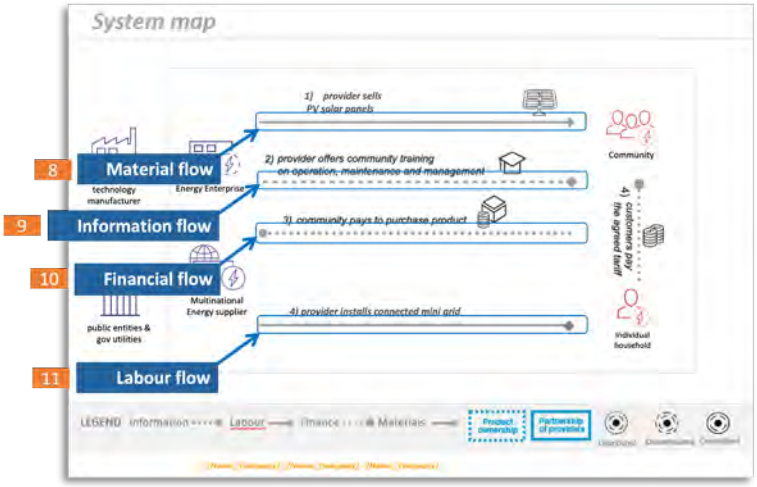


Fig. 4.40 Types of interaction flows (System Map for S.PSS and DE)

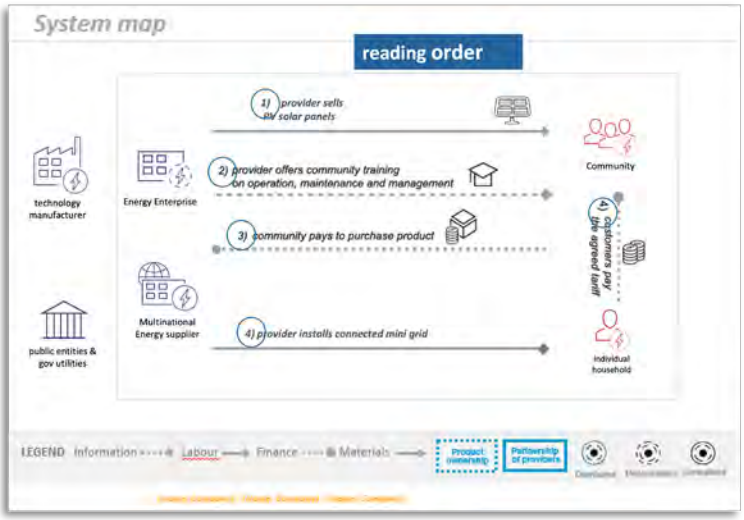


Fig. 4.41 Numbering of interaction flows (System Map for S.PSS and DE)

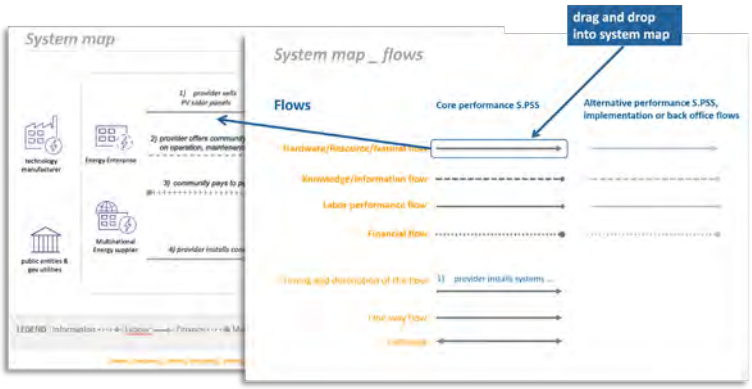


Fig. 4.42 Repository of interaction flows (System Map for S.PSS and DE)

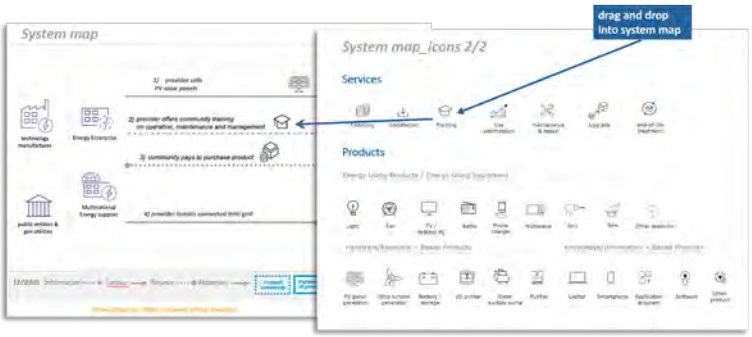


Fig. 4.43 Repository of interaction characterization icons (System Map for S.PSS and DE)

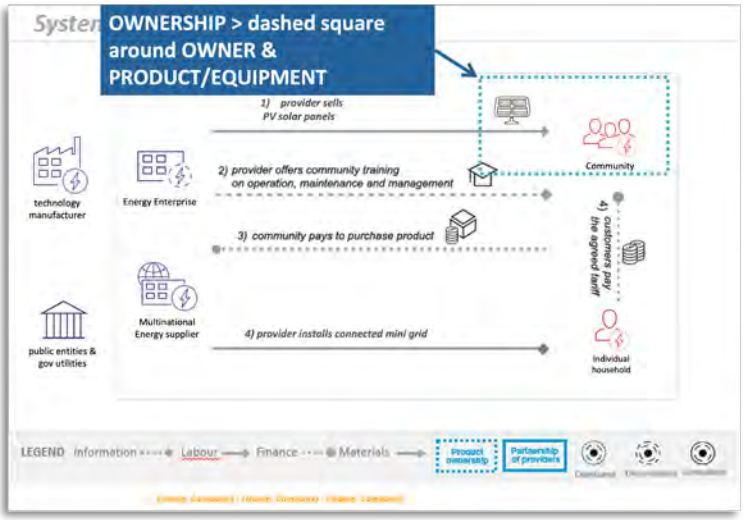


Fig. 4.44 Dashed squares indicating ownership (System Map for S.PSS and DE)

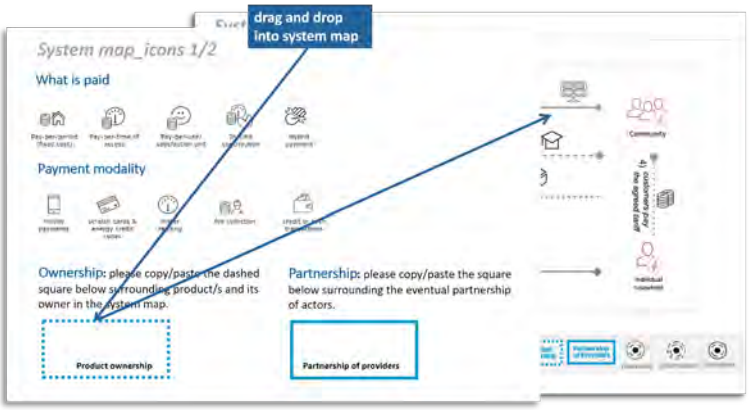


Fig. 4.45 Repository of Ownership squares (System Map for S.PSS and DE)

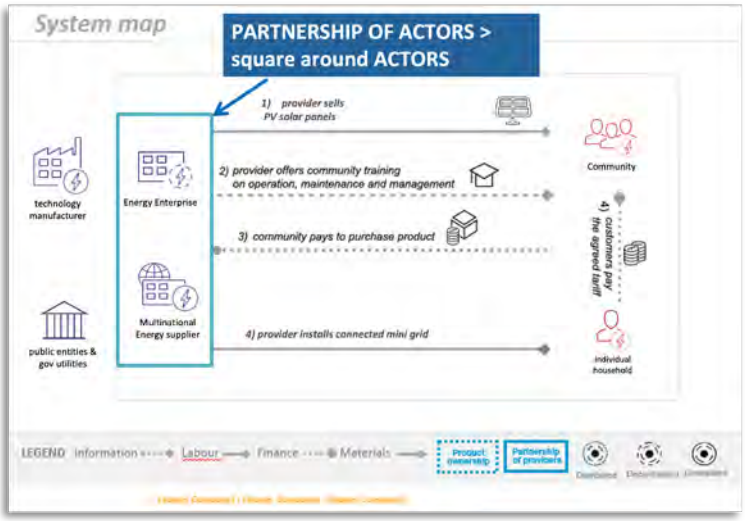


Fig. 4.46 Squares indicating partnership (System Map for S.PSS and DE)

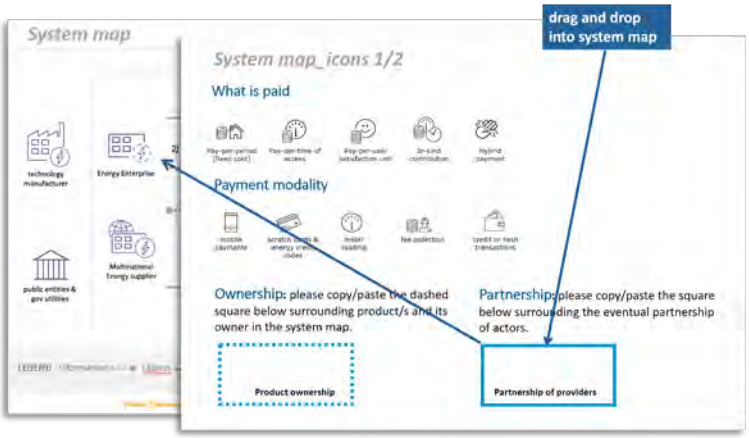


Fig. 4.47 Repository of Partnership squares (System Map for S.PSS and DE)

Availability and requested resources

The System Map for S.PSS and DE can be drawn up on paper without using any software. It is however advisable to use a slideshow software, to facilitate better management and modifications. The System Map for S.PSS and DE with

labels and icons repositories are available to download for free at www.lens-international.org, "Tools" section. The tool is based on a layout and set of standardized icons, usable with PowerPoint reader. 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 with no special graphical skills being required. The time required to set up a System Map for S.PSS and DE depends on the level of details along the design process; nevertheless, it could range from approximately 60-90 minutes.

Similar tool
This chapter has presented the tool – System Map for S.PSS & DE. Another type-specific tool - System Map for S.PSS & DG (Distributed energy Generation) has been developed to support visualization and configuration of the DG-specific system structure while co-designing. This is being done by indicating the actors involved and their interactions in the system, providing additional support to its users that are defining DG configuration. System Map for S.PSS & DG could be found in the book "Designing Sustainable Energy for All" (Vezzoli et al., 2018) chapter 7.2.7

4.2.7 Interaction Table

Aims
The objective of the Interaction Table (Fig. 4.48) is to design (co-design) and visualise the functioning of the system as a set of narratives over time (one story for each stakeholder), of both the front-desk (with the clients) and back-stage interactions (between other stakeholders).

What it consists of
The tool consists of a graphical representation containing each actor per row:

- The sequence of images with short text, representing (in time) the various actions of each stakeholder
- A short text, describing the specific role played by each stakeholder in each single action + a narrative of the

scenario

- The product and services delivered in each action (highlighting ownership, LC responsibilities and provider)

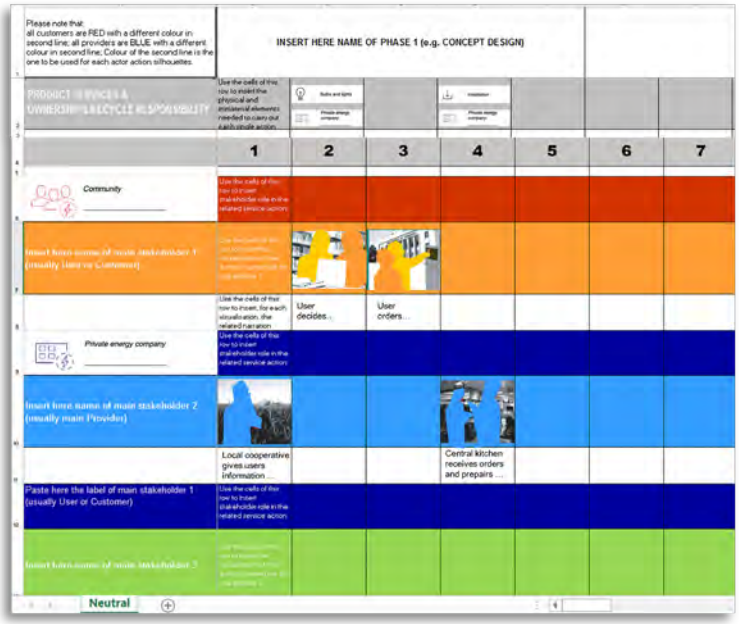


Fig. 4.48 Overview of the Interaction Table

Integration into the MSDS design process

The Interaction Table can be used at different stages of the MSDS Method (Fig. 4.49):

- Within the strategic analysis, **analyzing the reference structure** can be used to analyze the existing system describing various interactions
- The stage of **Product system concept design** can be used to design and visualize the interactions of the developed concept
- Also, the stage of **Product-service system detailed design** can be used to a further development (in detail) of all the system interactions

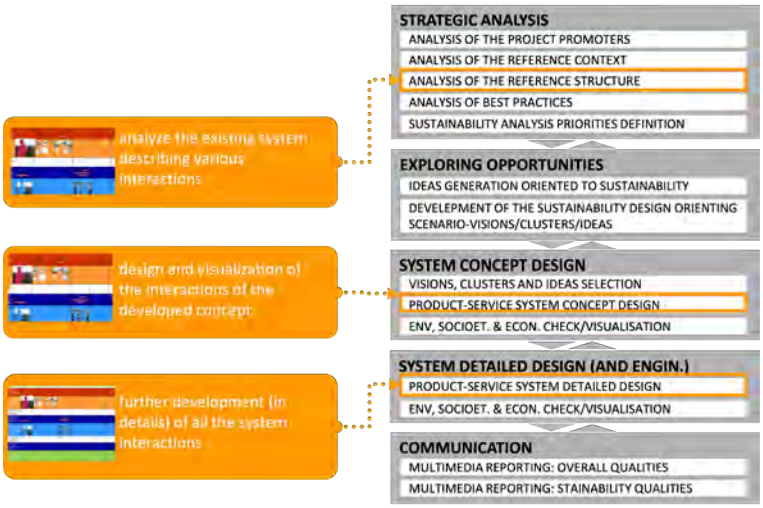


Fig. 4.49 Integration of the Interaction Table into the MSDS design process

How to use *Interaction Table*

The first step after downloading the tool is to open the excel file "Interaction Table". The table is composed by:

- First row: represents process phases (Fig. 4.50)
- Second row: hosts both products and services needed to carry out each single action, with the indication of products ownership/life cycle responsibility and service provider (Fig. 4.50).
- Other rows: represent each actor involved with her/his activities in the system (Fig. 4.50). The customer's row is represented with a red band (Fig. 4.51), the ones of other stakeholders in blue (Fig. 4.51). Different colour codes are used to identify specific stakeholders (e.g., orange, light blue, green)
- First column: presents the actors of the system divided as *customer* (magenta) and *providers* (blue) (Fig. 4.52)
- Other columns/row: presents the sequence of all activities happening in the system (Fig. 4.52)

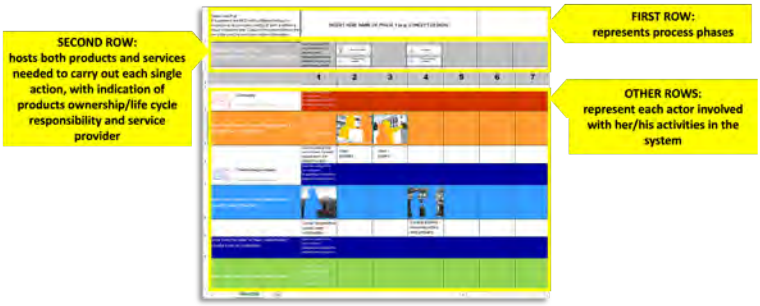


Fig. 4.50 Composition of the Interaction Table (1)

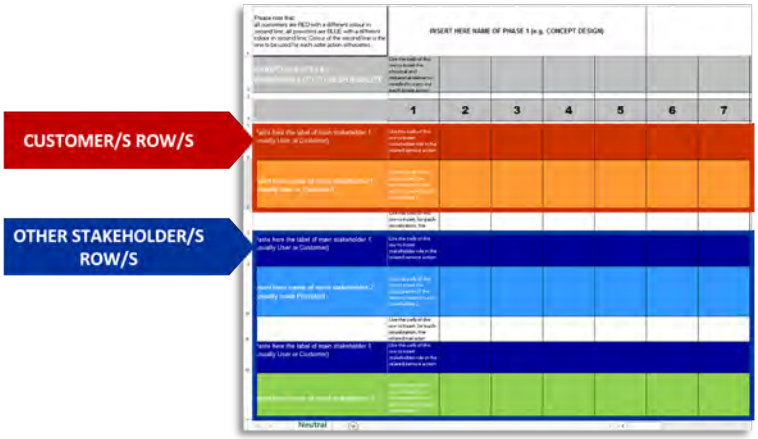


Fig. 4.51 Composition of the Interaction Table (2)

Fig. 4.52 Composition of the Interaction Table (3)

Now it is time to insert stakeholders' labels within the designated area. Labels can be taken from the other tabs of the Excel file, respectively named "Labels provider", "Labels customer" and "Labels Products & services" (Fig. 4.53). Alternatively, if actors have been already defined with the Innovation Diagram tool (see paragraph 4.2.1) or other tools, they can be dragged and dropped from there (Fig. 4.54).

Fig. 4.53 Different labels contained within interaction table different tabs

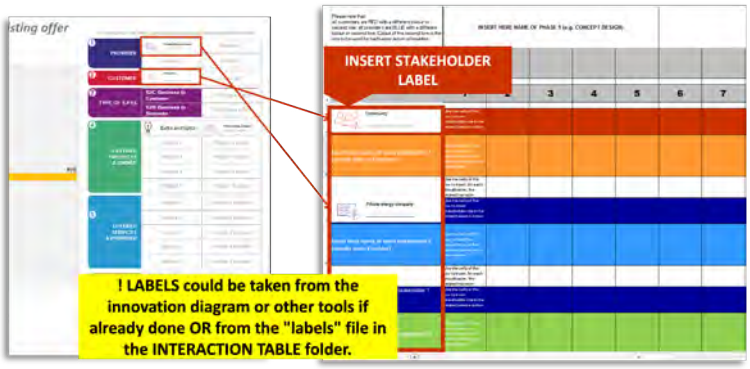


Fig. 4.54 Placement of labels in the interaction table

Continue filling the table with the definition of the activities of the system. Firstly, define the role of stakeholders within each process phase and the corresponding activity that is carried out. An image is included as well, and it should contain only necessary elements. Stakeholders are represented by their colours (e.g., light blue) and a back-

ground representing the context of each action (possibly black and white). (Fig. 4.55) Images can be taken from the "Image Library" available on www.lens-international.org, "tools" section (Fig. 4.56). If needed, they can be designed autonomously (and welcome to be added on the repository to improve it). Other element labels are placed on the first row to represent the product and its owner, or the service and its provider (Fig. 4.57). Labels can be taken from within different tabs of the Interaction Table Excel file, from the Innovation Diagram, or from other tools in case it has already been designed.

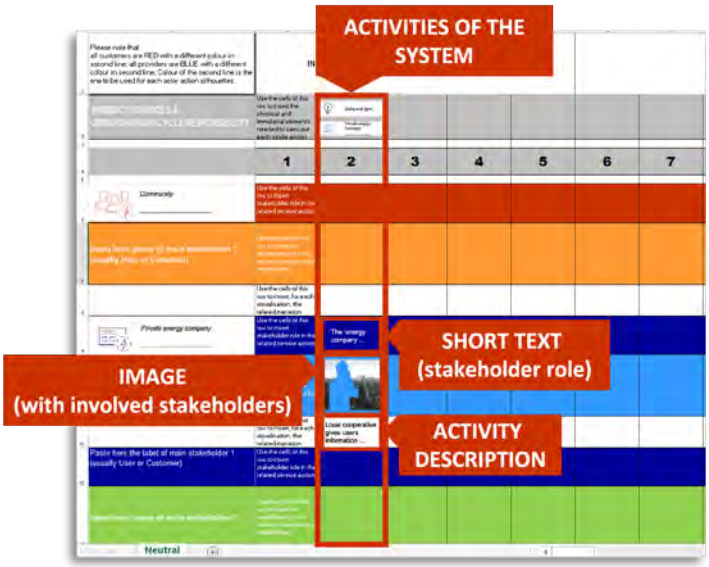


Fig. 4.55 Defining the Interaction Table of the system

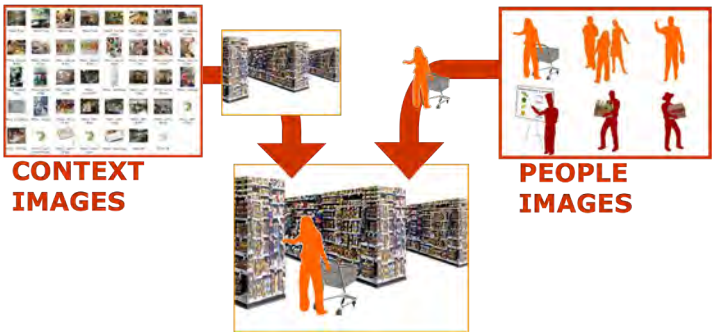


Fig. 4.56 Assembling image (Interaction Table)

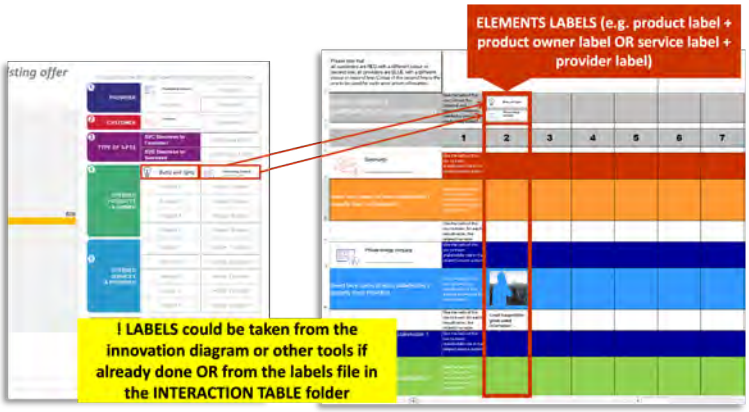


Fig. 4.57 Other elements labels (Interaction Table)

Availability and requested resources

The Interaction Table, as well as the "Image library", is an open-source tool that can be downloaded for free from www.lens-international.org, 'Tools' section. A computer and an Excel reader are required to use the tool. The Interaction table requires from 60 to 120 minutes to be completed.

4.2.8 Stakeholders Interaction Storyboard

Aims

The objective of the Stakeholders Interaction Table (Fig. 4.58) is to show a fluent narration of the functioning system, to the client or other actors involved in the project.

Fig. 4.58 Stakeholders Interaction Storyboard

What it consists of

The tool consists of a graphical representation containing in one single row the sequence of images and texts, representing the main interactions of the different stakeholders over time.

Integration into the MSDS design process

The Stakeholder interaction storyboard can be used during the **system concept design** to show a draft sequence of interactions within the system.

It is also used during the **product-service system detailed design** to show the final version of the sequence of the system interactions.

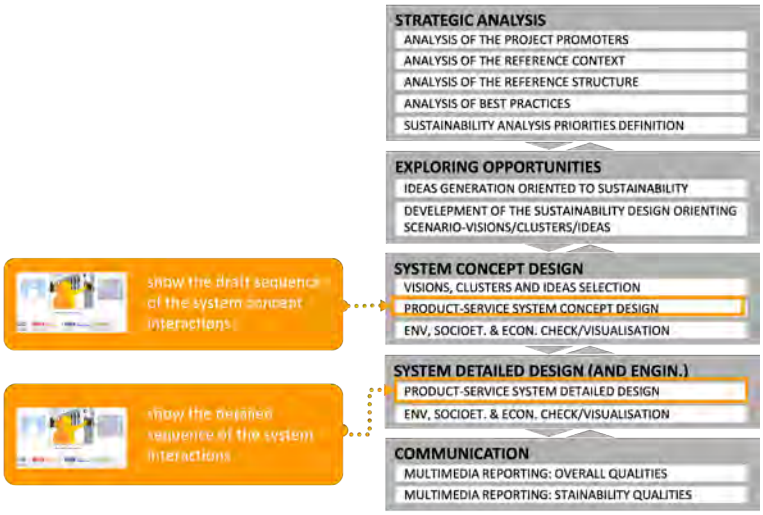


Fig. 4.59 Integration of the Stakeholders Interaction Storyboard within the MSDS Method

How to use *Stakeholders Interaction storyboard*

The tool (Fig. 4.60) is composed by a central scene of the action with background and coloured actors' silhouette (1), where the number of the action is also reported in the narration sequence (2). Below the main scene there is a narrative description of the action (3) and finally a legend (4) with the labels that identify the actors which are in the scene (customers, providers or others).

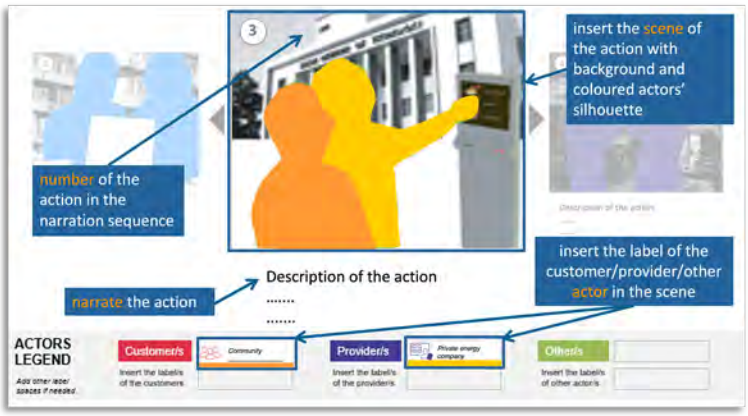


Fig. 4.60 Composition of the Stakeholders Interaction Storyboard

In case an Interaction Table has been already made (see paragraph 4.2.7), the same images and stakeholder labels and narrations can be used to assemble the Stakeholders Interaction Storyboard (Fig. 4.61); otherwise, images can be taken from the "Image Library" available on www.lens-international.org ("tools" section), if needed, they can be designed autonomously (and be added on the repository to improve it). Actors' labels can be copied and pasted from the Interaction Table in case it's already made (Fig. 4.62). Otherwise, they are available in the repository and can be copied and pasted in the Actors Legend, combining actors' type label with offer type characterising icon. Then identify and write their names. In case an icon is not available, you can use the label with "other actors" (Fig. 4.63). Once labels are copied inside the Stakeholder Interaction Storyboard, remember to underline them with the respective stakeholder colour to enhance its characterization. Then, write the narrative text under the scene image, or copy and paste the narrative text from the Interaction Table in the same way as before (Fig. 4.64). It is suggested to write the narrative text in the third person. To prepare a screen display of the interaction storyboard, it is important to narrate the storyboard frame by frame, in a sequence of slides (Fig. 4.65). While each slide has 1 scene, the scenes before and the one after should be shadowed and smaller in size (it could also be animated as a video). If a printing version of the storyboard is requested, all the frames should remain the same format and size in a linear order to display (Fig. 4.66).

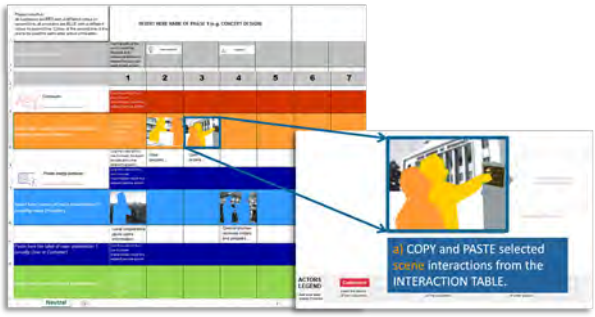


Fig. 4.61 Copying scene images from Interaction Table and pasting into Interaction Storyboard

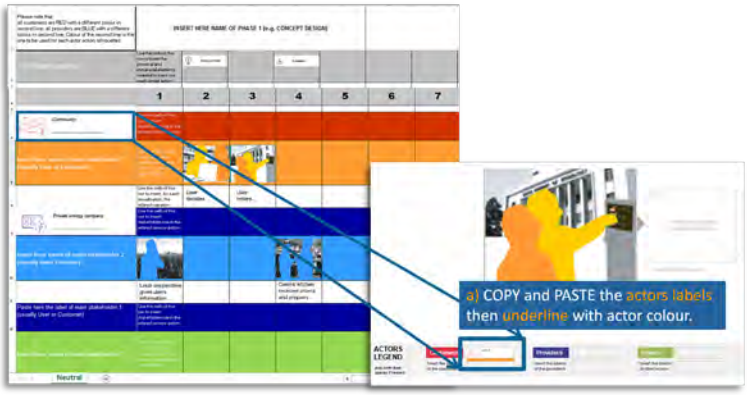


Fig. 4.62 Copying actor labels from Interaction Table and pasting into Interaction Storyboard

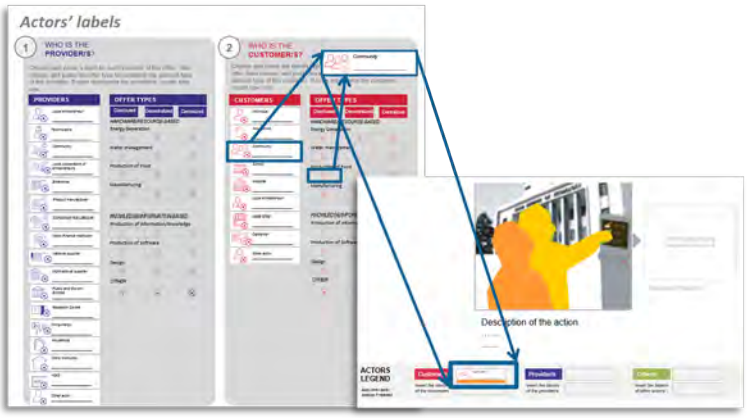


Fig. 4.63 Composition of the actor labels (actors' type label + offer type characterising icon)
and pasting into the Stakeholder Interaction Storyboard

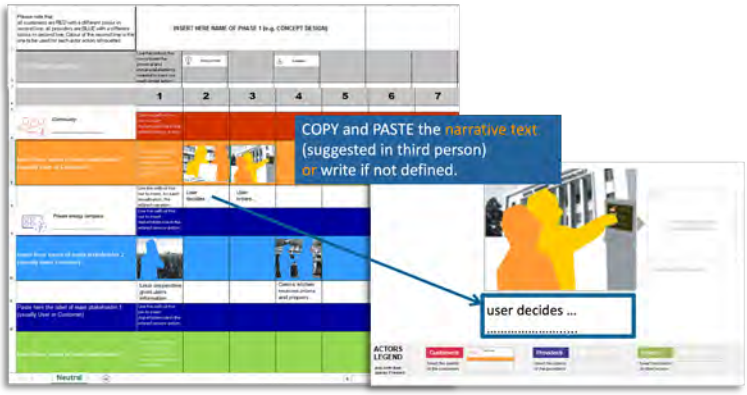


Fig. 4.64 Copying narrative text from Interaction Table and pasting into Interaction Storyboard

Fig. 4.65 The sequence in Interaction Storyboard

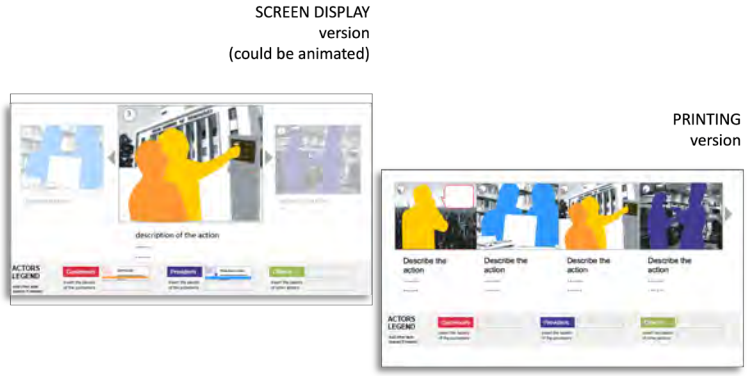


Fig. 4.66 2 versions of Interaction Storyboard

Availability and requested resources

The Stakeholders Interaction Storyboard, as well as the "Image library", is an open-source tool that can be downloaded for free from www.lens-international.org, 'Tools' section. It comes in two versions: one for screen display and one for printing. A computer and a PowerPoint reader are required to use the tool. The storyboard requires around 60 minutes to be completed.

4.2.9 Satisfaction Offering Diagram

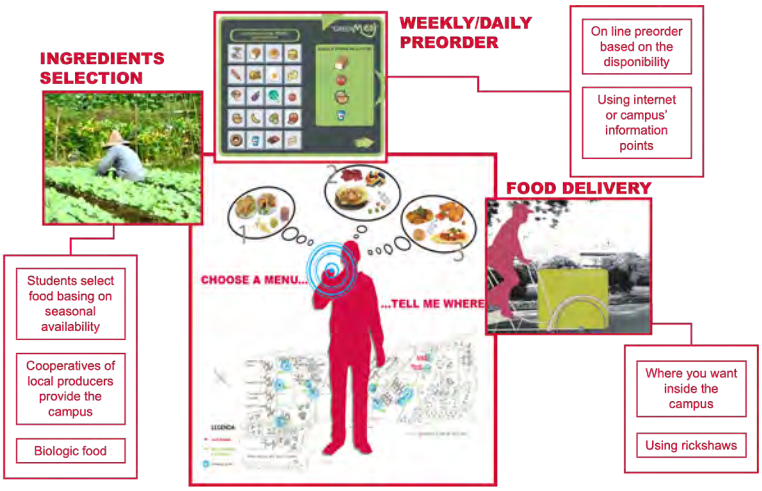


Fig. 4.67 Satisfaction Offering Diagram

Aims:
The objective of the Satisfaction Offering Diagram (Fig. 4.67) is to describe in brief the satisfaction offered to the user/customer, and how this is delivered.

What it consists of:
It is a graphical representation containing:
- the visualization of the core satisfaction provided by the system
- the visualization of the sub-offers (through which the satisfaction is delivered)
- the description of how the sub-offers are delivered

Integration into the MSDS design process
The Satisfaction Offering Map can be used in several stages of the MSDS Method (Fig. 4.68):
- During the exploration of opportunities, **generating sustainability orientated ideas**, is used to describe different emerging ideas indicating their main delivered satisfaction
- **Product-service system concept design**, is used to describe the concept of offer delivered by the system and specify its sub-offers
- In the stage of **system detailed design** explain in detail how the sub-offers are delivered by the system.

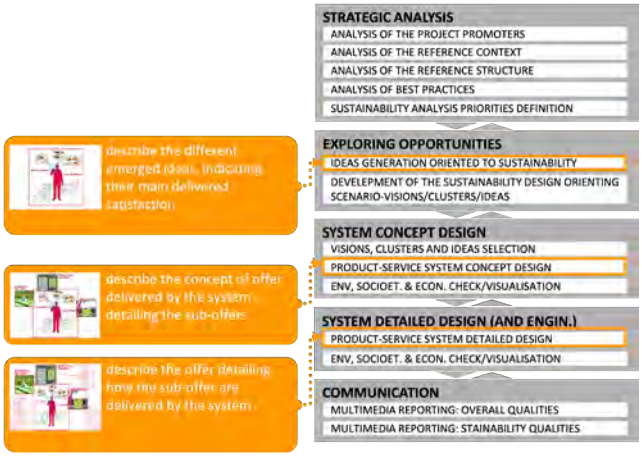


Fig. 4.68 Integration of the Satisfaction Offering Diagram within the MSDS methodology

How to use *Satisfaction Offering Diagram*

To begin with, the core delivered satisfaction should be defined with a set of images (and texts) that well enhance the offer that is provided by the solution (Fig. 4.69). Successively, images and short text are used to describe the sub-offer provided by the system (out of the inner square), i.e., a detailed definition of the satisfaction offered, which is also supported by additional captions of how it is provided (Fig. 4.70).

Fig. 4.69 Satisfaction offering diagram: the core satisfaction

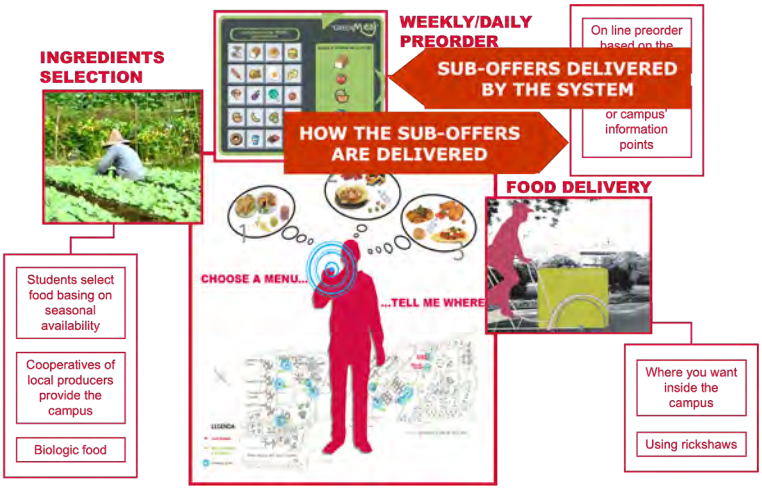


Fig. 4.70 Satisfaction offering diagram: the sub-offer and its description

Availability and requested resources

The Satisfaction Offering Diagram is an open-source tool that can be downloaded for free from www.lens-international.org, 'Tools' section. A computer and a graphic software (Photoshop, Illustrator, PowerPoint etc) are required to use the tool. The Satisfaction Offering Diagram requires around 60 minutes to be completed.

4.2.10 Animatic for S.PSS and DE

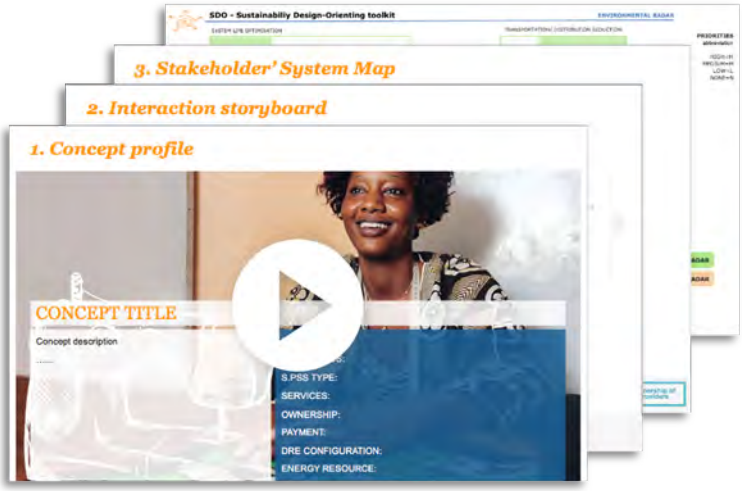


Fig. 4.71 Animatic for S.PSS and DE

Aims
The objective of the Animatic for S.PSS and DE (Fig. 4.71) is to produce a short video to present an S.PSS concept to engage the discussion with other actors (involved / to be involved and internal or external to the organisation).

What it consists of:
An audio-visual content based on a slideshow and made by a combination of:
- Animation of static images and texts
- Audio narration.

Integration into the MSDS design process
- The Animatic for S.PSS and DE can be used during the **product-service system concept design** phase to discuss or visualize the solution together with project promoters and other involved actors.

- It is also meant as a tool during the communication phase, in multimedia reporting the **overall qualities or sustainability qualities** of the project to visualize and promote the designed S.PSS and its sustainability ben-

efits.

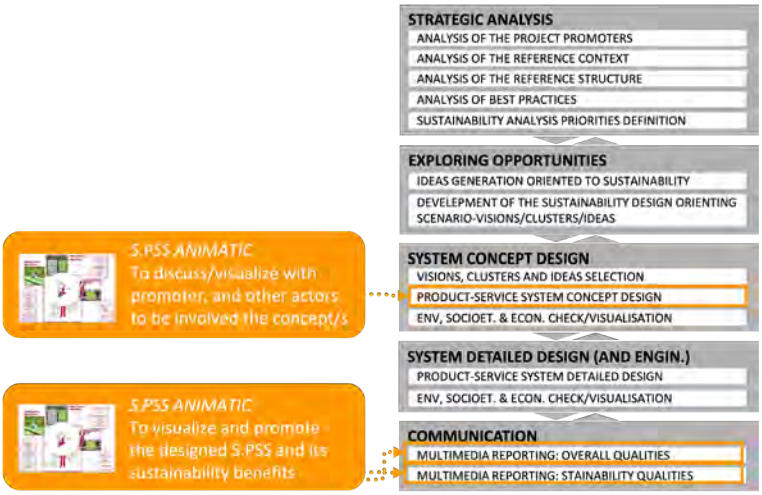


Fig. 4.72 Integration of the Animatic for S.PSS and DE within the MSDS method

How to use *Animatic for S.PSS and DE*

The creation of an Animatic for S.PSS and DE is based on four different steps:

a. Create/structure the slideshow (Fig. 4.73)

The S.PSS should be first described and detailed with five slides containing: the Offering Map (4.2.9); the Storyboard (4.2.8); the System Map (4.2.6); a rendering of evidence (e.g., product sketches) and the radar diagrams from the SDO Toolkit (4.2.2).

b. Animate each single element

Successively, single elements within the slides have to be animated to facilitate the progress of the narration.

c. Save the file

Remember to save the file on your computer as a video file format.

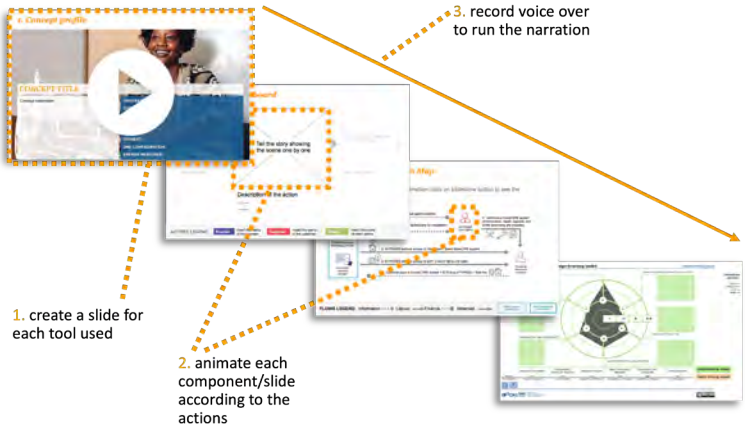


Fig. 4.73 Elements for the creation of the Animatic for S.PSS and DE slideshow

To produce an Animatic for S.PSS and DE with good quality, some suggestions can be followed:

- Make a 3 min. (max 5 min.) animatic
- Record the animatic with good audio
- Avoid recording over transition between one slide and the other
- Make the animatic understandable even for external auditors

Availability and requested resources

The Animatic for S.PSS and DE is an open-source tool that can be downloaded for free from www.lens-international.org, 'Tools' section. A computer and a PowerPoint reader are required to use the tool; video-editing software could support the editing part (e.g., Adobe Premiere Pro, Adobe After Effects etc). The Animatic for S.PSS and DE requires around 120 minutes to be completed.

4.2.11 Strategic Analysis Toolkit (SAT) for DE for Socio-Economic Ecosystems (SEE)

Aims

The Strategic Analysis Toolkit (Banerjee, Upadhyay and Punekar, 2021) aims to help designer in Sustainable Prod-

uct-Service System Design, with an intervention focus on Socio-Economic Ecosystems (SEE) of multi-cultural and diverse communities engaged in distributed economic activities.

What it consists of:
It consists of tools which:
- Identify the actors and their activities in the ecosystem;
- Identify the infrastructure and needs of the actors;
- Clarify the goal, define the problem statement, design brief and unit of satisfaction using participatory design tools;
- Helps in competitor analysis

Integration into the MSDS design process
The strategic analysis toolkit (SAT) can be used in the **Strategic Analysis** phase:
- To identify and analyse actors and aspects of their activity
- To identify existing infrastructure and required transformations
- To formulate S.PSS problem statement, design brief and unit of satisfaction
- To analyse competitors

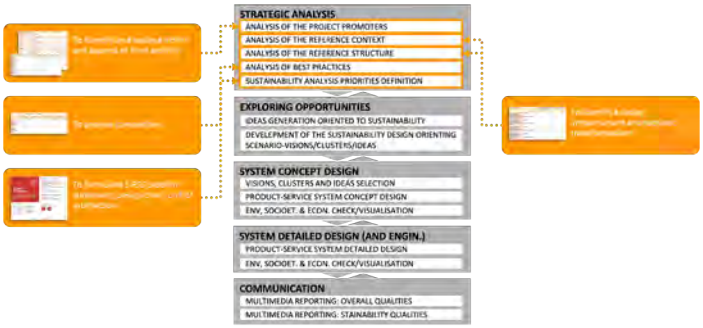


Fig. 4.74 Strategic analysis toolkit (SAT) integration into the MSDS design process

How to use *Strategic Analysis Toolkit (SAT) for DE for Socio-Economic Ecosystems (SEE)*
Process 1: Project Socio-Economic Ecosystem Analysis
1. Awesome Actors Tool: The first step of strategic analy-

sis is to identify all the actors and their aspects of activity. This is best accomplished by interviewing local administrators and visionaries (e.g. local elders, thought leaders, NGOs, etc.). The Awesome Actors Tool helps its users to identify the main value proposition of the local ecosystem, its problems, its actors and their activities (Table 4.2).

2. KFPS Knowledge Mining Tool: This tool helps to identify existing infrastructure and required transformations. Interviewing local administrators/visionaries helps in acquiring information on service, product-service, and infrastructure transformations planned and required in the local ecosystem (Table 4.3).
3. Empathy Mapping, AEIOU Mapping, Value Opportunity Analysis, SWOT, PESTLE, System Map: A set of tools that support their users in meeting the actual actors and understanding their needs. An example can be seen in Table 4.4, showing e.g. Value Opportunity Analysis tool.

Process 2: Defining intervention context

4. Co-design using "Clarify Your Goal": This tool, adopted from Frog Design (Frog design, 2016) helps to define design goals, identify the problem statement, design brief and unit of satisfaction (Fig. 4.75).
5. Competitor analysis on form, category, generic, budget level (using Porter's five forces analysis if applicable (Porter and Kramer, 2006): This tool helps to collect competition space knowledge (Table 4.5). Competitors of the system are found based on the clarified goal of the design intervention and the main value proposition of the local context.

Currently the toolkit has been designed and tested on two SEE contexts, both located in Assam, India.

Availability and requested resources

Downloadable files of each tool can be found in Banerjee et al. (Banerjee et al., 2019) with the following information on resources and time needed to carry out design processes using each tool.

Type of actor	Name of actor	Contribution	Value added	Motivation	Problems solved	Challenges faced	Tools used
Knowledge actors		What they are doing?	What value does the actor bring to the ecosystem?	What value does the actor choose to do what it does?	What are the problems that the actor is trying to solve?	What stops it from performing activities?	How do they interact with other actors in the system?
Production actors							
Service actors							
Finance actors							
Administration actors							
Market actors							
Customers/ clients							
Other actors							

Table 4.2 Awesome actors tool

Types of Infrastructure		Existing conditions: Is the existing condition sufficient?	Transformation required
Knowledge Infrastructure: (School colleges, data banks, information portals, traditional knowledge etc.)	Overall		
	Specific Stakeholder		
Financial Infrastructure (credit, banking, loans, insurance and providing bodies etc.)	Overall		
	Specific Stakeholder		
Physical Infrastructure (Transportation, built environment, energy, water etc.)	Overall		
	Specific Stakeholder		
Social infrastructure (Socio-cultural norms, governing bodies, associations etc.)	Overall		
	Specific Stakeholder		

Table 4.3 KFPS knowledge mining tool

What are the needs of the actors?		Actor 1	Actor N
Emotion	Adventure		
	Independence		
	Security		
	Sensuality		
	Confidence		
	Power		
Aesthetics	Visual		
	Auditory		
	Tactile		
	Olfactory		
	Taste		
Identity	Point in Time		
	Sense of Place		
	Personality		
Impact	Social		
	Environmental		

Table 4.4 Value opportunity analysis


CLARIFY YOUR GOAL

Agree on the problem you're trying to solve and what goals you want to achieve. This activity area is critical to your group's success, as your goals may change depending on what you learn here.

CLARIFY YOUR GOAL / THINGS TO KEEP IN MIND

Keep a visual record of how your goal evolves
Remind your group of their goal and how they're moving towards it by visually documenting the process. Hang things up on the walls, keep stacks of paper with old drawings, and photograph your time together. This will serve as a record of your progress and as inspiration for future work.

Stock up on the right supplies
Most activities in this toolkit require no more than paper and pens. However, there are suggestions for extra supplies that may help your group use your time more effectively.

Be aware of your shared values
Openly discuss with your group what's important to you and how you like to work, so there aren't big surprises when you take on big challenges.

Identify your learning
Filling out a Learning Card can help your group to assess what you've learned or determine next steps after each activity or section of the action map.

Make sure you're having fun
Things may become very serious while your group is working, so remember to laugh and celebrate along the way. You're accomplishing great things!

CLARIFY ACTIVITIES

RIPPLE EFFECT
Decide what kind of impact you want your group to have—from improving people's lives in your community to changing your country or the world.

DEFINE YOUR PROBLEM
Define the problem your group wants to tackle and establish key questions to answer along the way.

FIND TRUE NORTH
Agree on the goals your group wants to achieve and when you want to achieve them.

CHECK YOUR GOAL
See if anything has changed about your group's goals and make adjustments.

SUGGESTED SEQUENCES

Define your goal when your group meets for the first time.

frogdesign.com/GAT

Fig. 4.75 "Clarify Your Goal" section of Frog Collective Action Toolkit

	Form		Category		Generic		Budget	
	Competitor name	Value offering	Competitor name	Value offering	Competitor name	Value offering	Competitor name	Value offering
Local-Ecosystem's main value proposition								
Design intervention goal								

Table 4.5 Competitor analysis on form, category, generic and budget levels

4.2.12 Distributed Manufacturing (DM) Applied to PSS Design Toolkit

The DM applied to PSS design toolkit (Fig. 4.76) has been tested with students, experts, manufacturing industry professionals and design practitioners through three rounds of empirical application to ensure its effectiveness and usability (Petrulaityte et al., 2020).

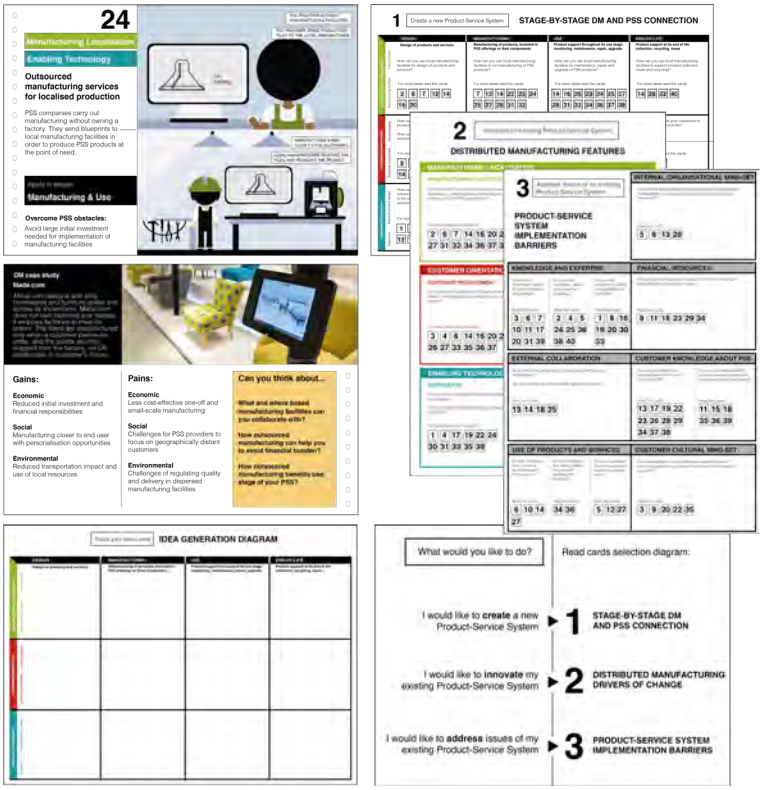


Fig. 4.76 The DM applied to PSS design toolkit

Aims

The DM applied to PSS design toolkit serves two purposes: (1) it provides its users with knowledge about potential DM opportunities and (2) supports idea generation for PSS solutions improved with DM features.

What it consists of:
The toolkit consists of four elements, each of which is described below in detail:

- 40 near-future scenario cards
- 3 scenario cards' selection diagrams
- 1 introductory card
- 1 idea generation diagram.

Near-future scenario cards
Double-sided near-future scenario cards are brief snapshots illustrating how specific features of Distributed Manufacturing can be applied to Product-Service Systems throughout their life cycle (Fig. 4.77). Scenario cards are made to inspire and to encourage future-oriented thinking. Furthermore, they serve an educational purpose and contain sufficient amount of information to support a learning process about DM and PSS.

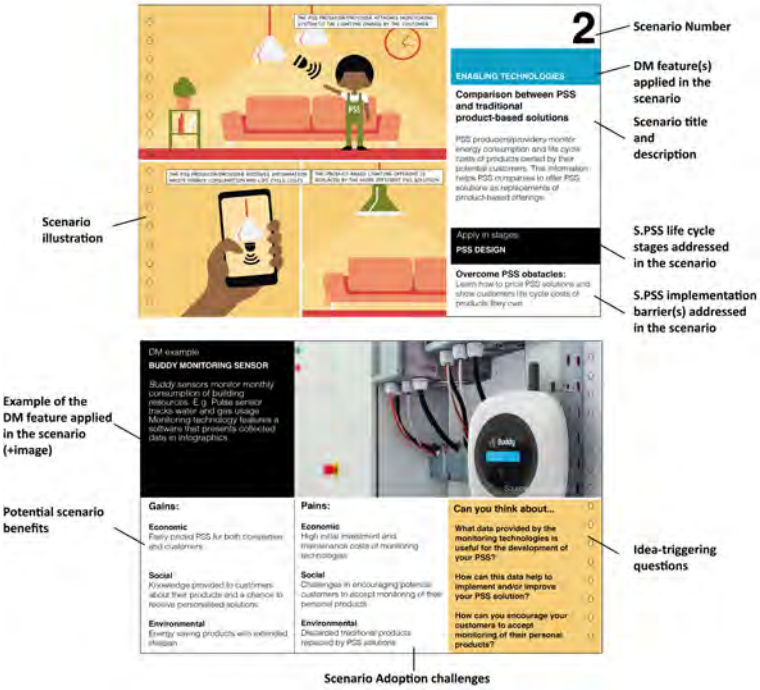


Fig. 4.77 Front and back sides of the near-future scenario card

Scenario cards' selection diagrams

Scenario cards' selection diagrams, which maps scenario cards, illustrate the areas tackled by the near-future scenarios. This toolkit contains three scenario cards' selection diagrams (Fig. 4.78): [1] the stage-by-stage DM and PSS connection diagram (1); [2] the DM features diagram (2); and [3] the PSS implementation barriers diagram (3). These diagrams are made to facilitate relevant scenario cards' selection. Each diagram classifies scenario cards according to PSS life cycle stages and/or DM features, or PSS implementation barriers, and contains questions helping to select relevant cards.

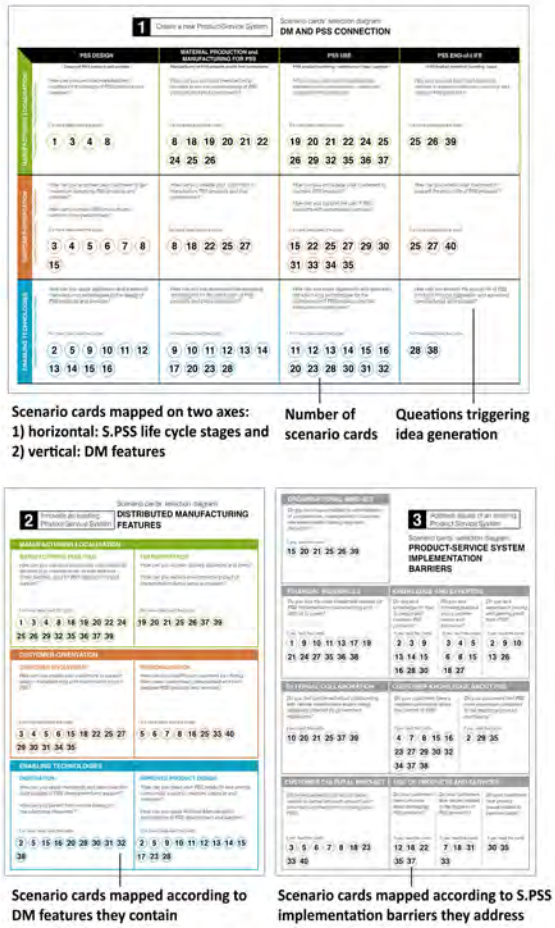


Fig. 4.78 Scenario cards' selection diagrams

Introductory card

This toolkit is made to facilitate new PSS development as well as to improve existing PSS solutions. The introductory card allows the toolkit's users to decide whether they would like to create a new PSS or to improve an existing one (Fig. 4.79). Depending on their choice, one of the three scenario cards' selection diagrams must be selected.

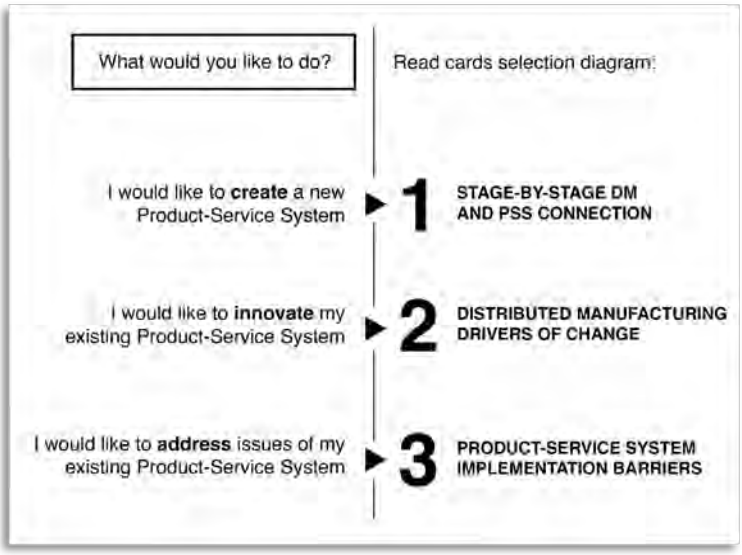


Fig. 4.79 The introductory card

Idea Generation Diagram

The Idea generation diagram (Fig. 4.80) is used for positioning ideas developed using near-future scenario cards.

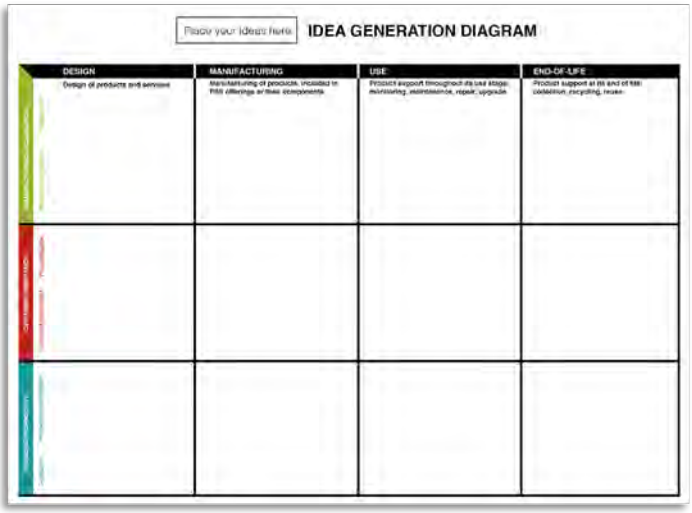


Fig. 4.80 Idea generation diagram

Integration into the MSDS design process

The DM applied to PSS design toolkit can be best used to facilitate idea generation for S.PSS solutions enabled by DM. In addition, near-future scenario cards can be used to explore and analyse existing examples of DM and learn about the DM potential. Finally, the idea generation diagram can be used to position, cluster and select promising developed ideas for further detailing (Fig. 4.81).

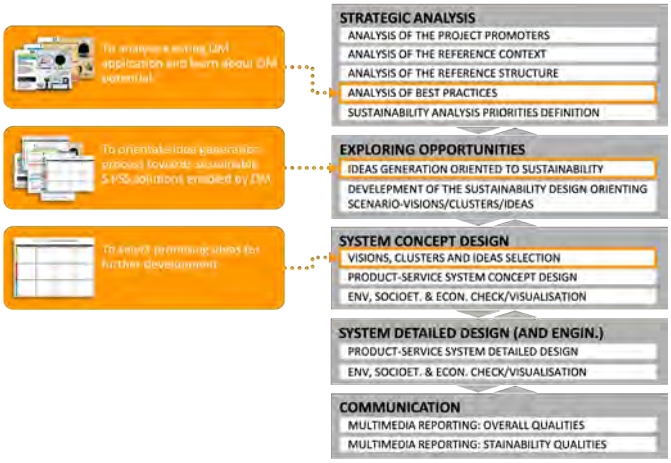


Fig. 4.81 DM applied to PSS design toolkit's integration into the MSDS design process

How to use the *DM applied to PSS design toolkit*

Each element of the DM applied to PSS design toolkit is created to be used in a defined order (Fig. 4.82): first, the identification of the goal using the introductory card (1); second, the selection of relevant scenario cards using the scenario cards' selection diagrams (2); third, DM applied to PSS idea generation using near-future scenario cards (3); and, finally, positioning developed ideas on the idea generation diagram (4).

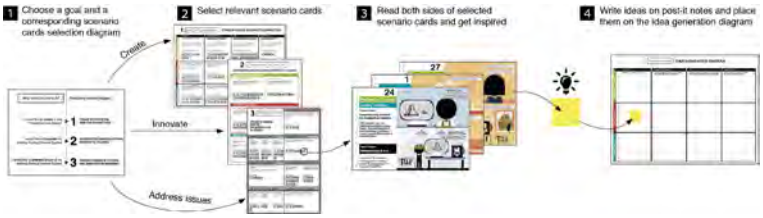


Fig. 4.82 A proposed design process of the DM applied to PSS design toolkit

Availability and resources required

The DM applied to PSS design toolkit is available for free download (from www.lensinternational.org, in "Tools" section). The toolkit needs to be printed and other required resources are post-it notes and pens.

The toolkit may be used by a team of designers, design students, or multidisciplinary team. It is advisable to involve various system actors. The toolkit requires at least 120 min to conduct a complete ideation process.

4.2.13 E.DG — Estimator for Distributed energy Generation

Aims

The tool (Vezzoli, Bacchetti and Ceschin, 2018) is developed to support the design of Distributed energy Generation (DG) systems, as well as to guide the evaluation of the energy demand and need of the designed system concept. In addition, it is used to assess the best system configuration and estimate the energy production potential (Fig. 4.83).

Fig. 4.83 S.PSS and DG estimator of DG load/need and production potential. Source designed by the Authors

What it consists of:

The tool is composed of six main worksheets (in one excel file):

1. Worksheet for energy load/need and energy production potential: it summarizes the energy load/need to satisfy the system appliances, and compares such data with the table that summarizes the energy production potential of the DG system (existing or designed);
2. Worksheet for Energy-Using Product (EUP) consumption database: it provides a list of the average power consumption (Watt) of the most common appliances such as washing machine, oven, etc.;
3. Four worksheets, one for each type of Distributed energy Generation (DG) resource: it allows to calculate the energy/gas production potential for a specific context, through the support of online databases and websites. The consisting worksheets are: (1) worksheet for photovoltaic system sizing, (2) worksheet for wind system sizing, (3) worksheet for hydro system sizing, and (4) worksheet for biomass digester sizing.

The tool integrates databases and websites to get data on the local availability of renewable resources (e.g. Geographical Assessment of Solar Resource irradiation) (Figs. 4.84, 4.85, 4.86 and 4.87).

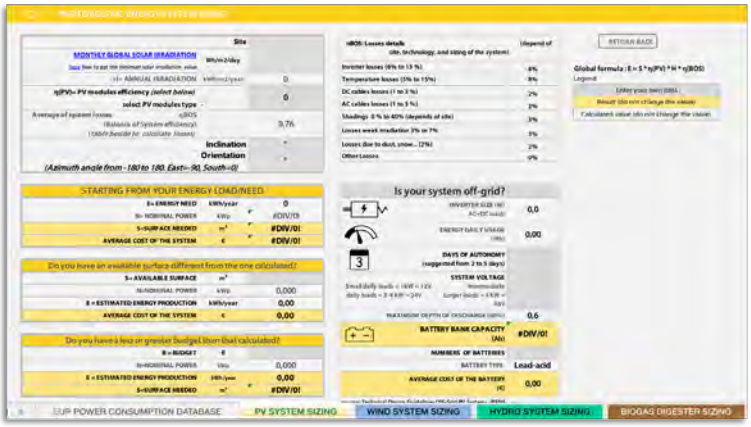


Fig. 4.84 Worksheet—solar energy. Source designed by the Authors

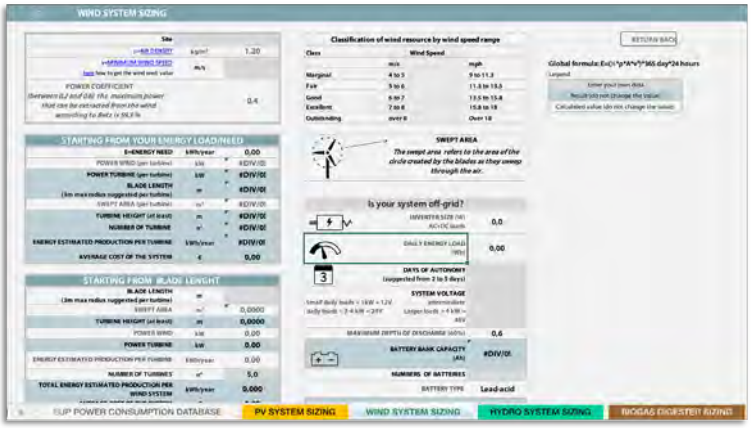


Fig. 4.85 Worksheet—wind energy. Source designed by the Authors

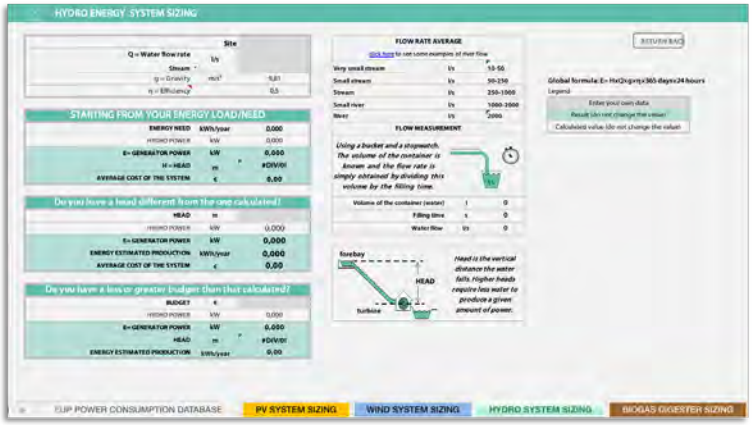


Fig. 4.86 Worksheet—hydro energy. Source designed by the Authors

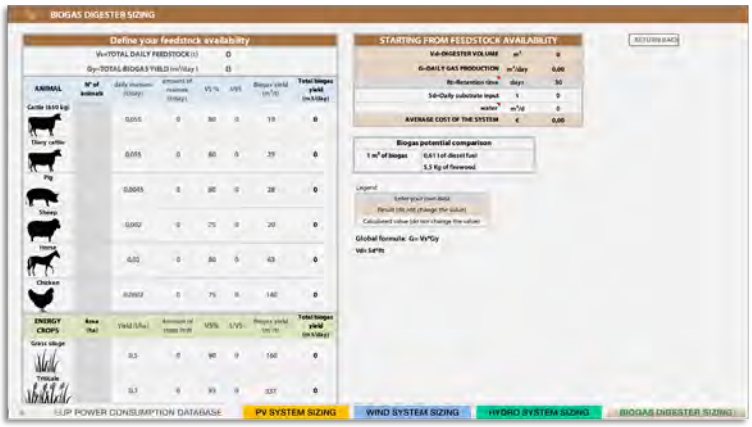


Fig. 4.87 Worksheet—biomass energy. Source designed by the Authors

Integration into the MSDS design process

The E.DG tool is used in the Design System Concept stage to draft the new DG systems, according to energy need and locally available resources.

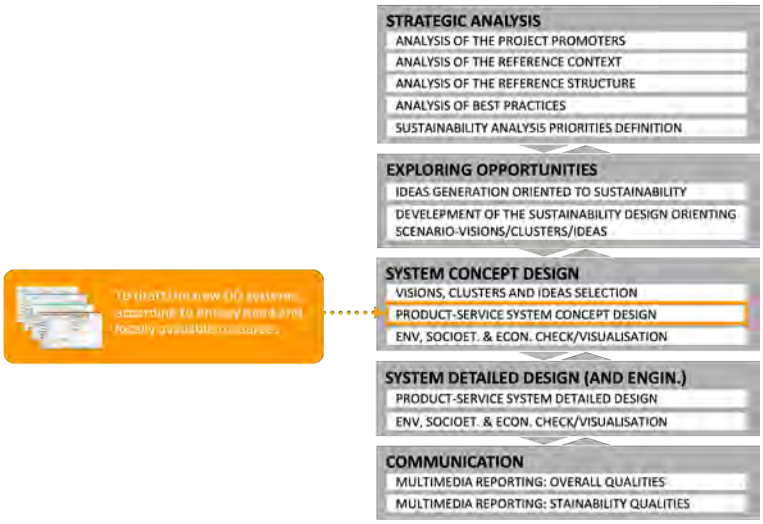


Fig. 4.88 Estimator for Distributed energy Generation's integration into the MSDS design process

Results

The result from the E.DG tools is a preliminary sizing of new DG systems, according to energy need and locally available resources.

How to use the *Estimator for Distributed energy Generation*

First step is to define the energy load/need (worksheets 1) to determine the (potential) energy consumption of the system. To support the definition of the energy need in relation to appliances, it is possible to choose from the database of appliances (worksheet 2). After, it is possible to compare the energy load/need emerged, with the energy production potential of the DG system designed (if any) to verify correspondence of energy need and energy availability. The second step is to size (or resize in case of existing) the DG system according to the energy need to be satisfied. To do this, it is initially needed to define the local renewable energy resource to be used: sun, wind, water and biomass (worksheets 3–4–5–6), and then to define the dimension of the system according to the energy/load need. A final check is possible (worksheet 1) comparing the energy load/need and the energy production potential

which has to (in average) correspond to the energy load/need.

Tool availability and required resources
The tool is available for a free download at www.lenses.polimi.it. It is available in digital version which could be used through a pc or a projector and requires internet connection to reach information from the online databases. The time required is approximately 60 min.

4.2.14 S.PSS + DG Innovation Map

Aims
The tool (Emili et al., 2018) can be used for classifying S.PSS models applied to DG, positioning a company's offers, analysing competitors in the market and exploring new opportunities. The tool can be also used for generating new concepts of S.PSS applied to DG.

What it consists of
The tool is composed of *Innovation Map*, *Archetypal Models Cards*, *Stakeholder Cards* and a set of *Concept Cards*.

The Innovation Map
This has been built as a classification system for S.PSS and DG models (Emili et al., 2018). The tool consists of a polarity diagram that combines different types of S.PSS models with the DG energy systems and it can be used to position companies and new concepts according to the type of business model and the technology involved.

The vertical axis distinguishes different types of S.PSS models, i.e. what is being offered to customers and what they pay for. The different S.PSSs types on the Innovation Map help users to classify energy solutions based on what the focus of the offer is (product, use or result-oriented) and what the payment structure is (e.g. pay-to-purchase a product with financing services, pay-to-rent or pay-per-energy consumed). The vertical axis also encompasses ownership structure and environmental sustainability poten-

tial.

On the horizontal axis, the different types of DG systems are illustrated: *mini kit*, *individual energy system*, *charging station*, *isolated mini-grid* and *connected mini-grid*. The horizontal axis also encompasses the type of target customers addressed in the S.PSS solution. It ranges from individual target (including the individual use of energy for households, entrepreneurs, productive activities, community buildings) to community target (which includes altogether a number of households, and/or productive activities, community buildings, public spaces, etc.) (Fig. 4.89).

The Archetypal Models Cards
These collect different types of S.PSS applied to DG with corresponding case studies and a system map that illustrates how the system works (Fig. 4.90).

The Stakeholders Cards
They aim at detailing actors and competitors involved in the energy scenario and at understanding their roles and responsibilities. These cards can be used during the strategic analysis of competitors (see next section) (Fig. 4.91).

The concept Card
This aims at providing a template for generating new concept directions of S.PSS applied to DG and it includes type of offer, network of providers, products, services, customers and payment channels. It can be used during the idea generation session (see next section) (Fig. 4.92).

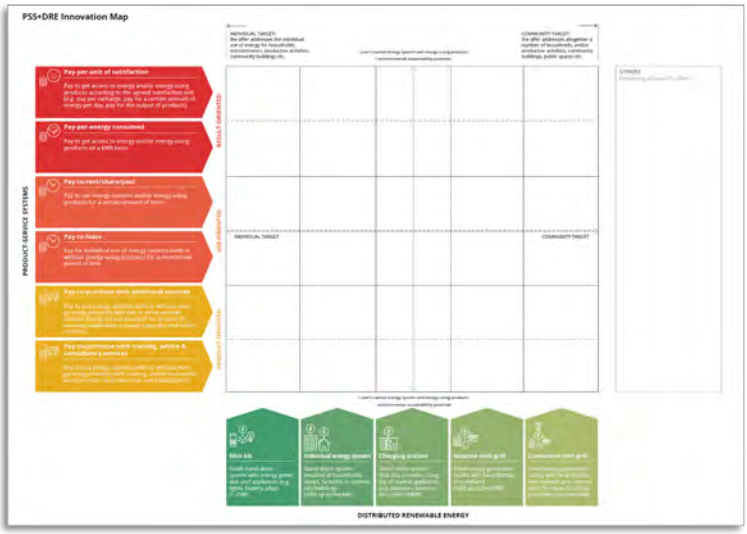


Fig. 4.89 S.PSS + DG Innovation Map (Emili et al., 2018)

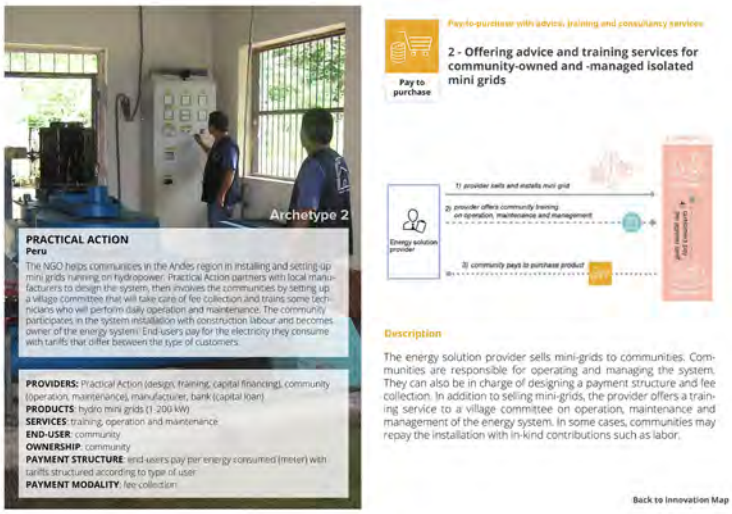


Fig. 4.90 Archetypes cards (Emili et al., 2018)

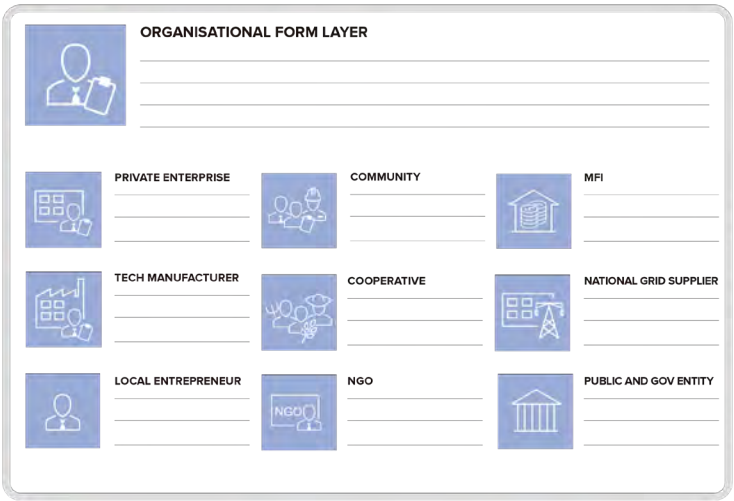


Fig. 4.91 Stakeholders card (Emili et al., 2018)

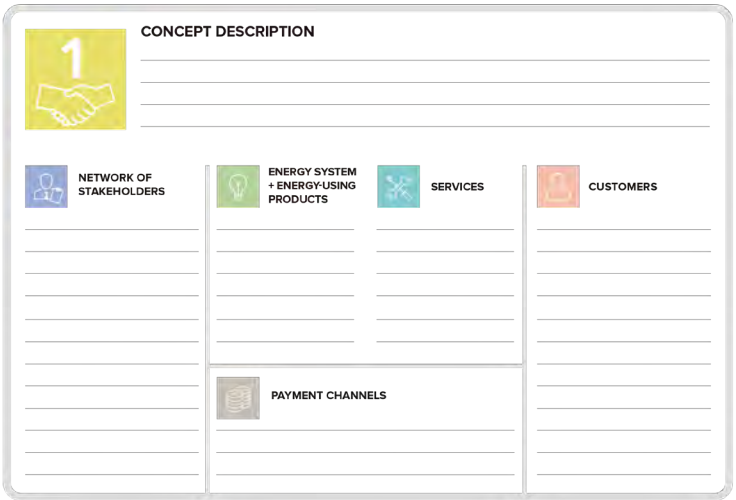


Fig. 4.92 Concept card (Emili et al., 2018)

Integration into the MSDS design process

The Innovation Map can be used for different purposes in the **Strategic analysis Exploring opportunities, and System concept design stages**.

Fig. 4.93 S.PSS + DG Innovation Map's integration into the MSDS design process

Strategic analysis

Position company's offerings on the map

The tool can be used to position a company's offerings according to the value proposition, type of energy system and target customer. Users can write down the company's offering on post-its (one offering per post-it), and place them on the map. The positioning should follow the type of S.PSS, i.e. product, use or result-oriented according to the specific payment structure and ownership model, and the type of DG system involved in the solution. It should be highlighted that one company may have multiple offerings, and therefore these can be positioned on various parts of the Map (Fig. 4.94).

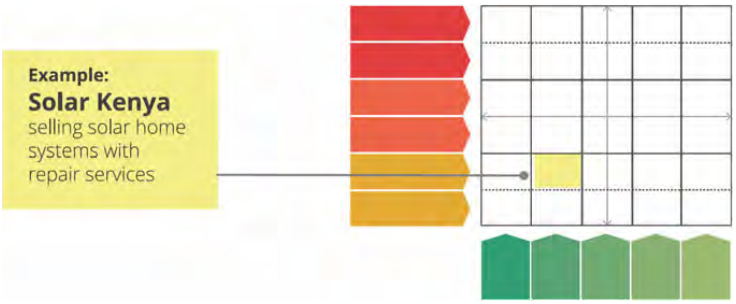


Fig. 4.94 Positioning of company's offerings on the innovation map. Source designed by the Authors

Map the competitors
Following the same criteria, companies operating in the selected context can be positioned on the Innovation Map, possibly using another colour of post-its. Users may want to focus on a specific technology (e.g. only mini-grid) or map all actors operating in a specific geographic area. If necessary, other offers that are not Product-Service Systems can be positioned in the box on the right-hand side of the Innovation Map (Non-PSS offers). These can include for example sale-based offers (e.g. sale of solar lanterns) or other complementary energy products (e.g. bioethanol fuel) (Fig. 4.95).

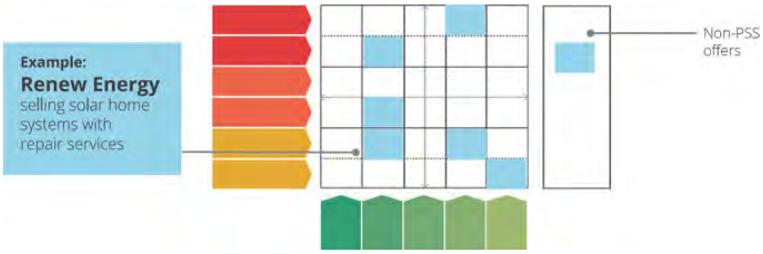


Fig. 4.95 Positioning of competitors on the innovation map. Source designed by the Authors

Strategic analysis of competitors: organisational form layer
To gather a deep understanding of the energy scenario, the tool can be used to detail the stakeholders that are providing energy solutions in a selected context and what roles and responsibilities they have. This phase aims at going more in-depth in analysing the target market by detailing the previously mapped solutions. The Stakeholder Cards can be used to define the actors involved and the roles they have. This phase can help users in understanding the main socio-economic actors operating in the energy sector in a specific area (Fig. 4.96).

Fig. 4.96 Example of a completed stakeholder card. Source designed by the Authors

Exploring opportunities

Select a promising area to explore

Having detailed the existing energy situation for the chosen context, users can focus on identifying promising areas to explore. This can be carried out but circling an area they want to focus on. It could be a specific technology (e.g. individual energy systems) or a type of offering, or both. Areas that have not been explored by competitors in the same context may be a good starting point for tapping promising markets. It must be highlighted that the tool does not provide indications on how to identify promising areas. Instead, it acts as a framework to trigger and stimulate discussion among the design team (Fig. 4.97).

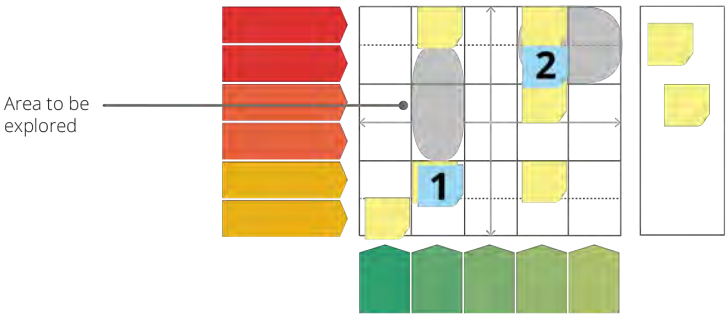


Fig. 4.97 Selection of promising areas to explore. Source designed by the Authors

Develop new concept directions
The Innovation Map can also support the design of new concepts of S.PSS applied to DG. For this purpose, the Concept Cards can be used to write down ideas, starting by describing the general type of offer users intend to provide. Then, the corresponding number of the Concept Card can be positioned on the Map, following the same criteria used to map companies' offerings. At this stage, it is advised to generate several concepts, which will be selected and refined at a later stage.

Then, for each concept, the card should be filled out by writing down ideas on customers, products and services, stakeholders and payment modalities. At this stage, the aim is to consider the several elements of the design solution, without necessarily going into detail (Fig. 4.98).

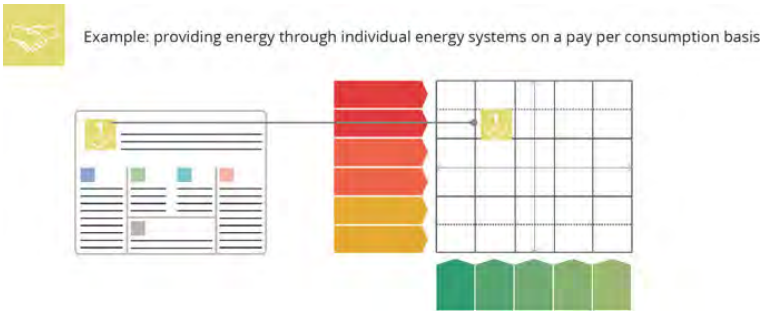


Fig. 4.98 Example of a completed concept card. Source designed by the Authors

System concept design
Select the most promising concept(s)
Once the phases of strategic analysis and concept generation are completed, the Innovation Map should provide a visualisation of existing businesses/competitors, stakeholders involved, promising areas to explore and new business concepts. This can be the starting point for a discussion within the company's management team about which concepts are more promising, what influencing factors need to be considered and to eventually select one or more options for further detailing.

Results

At the end of the process, the Innovation Map provides a picture of the current situation (position of company's offerings, competitors and stakeholders involved) and a selection of promising areas to be explored. The Innovation Map also supports the generation of an initial idea to identify new business opportunities (Fig. 4.99).

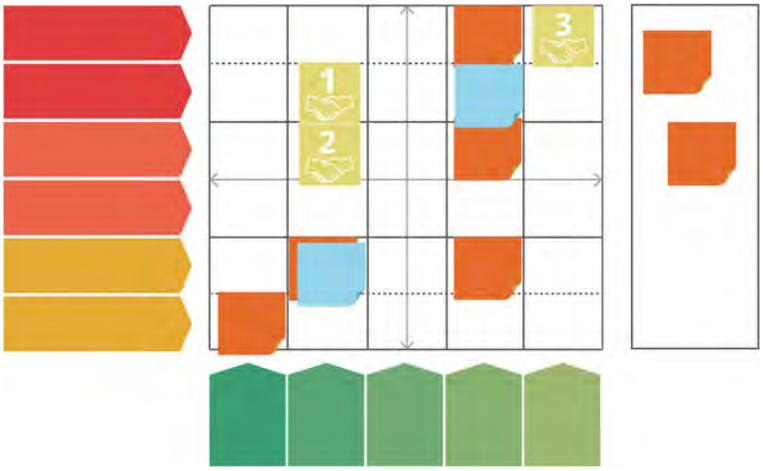


Fig. 4.99 Example of a completed innovation map. Source designed by the Authors

How to use the tool

The tool can be flexibly used in different stages of the design process: from the strategic analysis (e.g. positioning company's offers and its competitors) to the idea generation and concept development phase.

Availability and resources required

The tool is available for a free download at www.lenses.polimi.it and on www.se4alldesigntoolkit.com. The tool has been designed to be used in workshops and (co)design sessions, therefore, it is preferable to print it in a large format (at least A1). The time required for using the Innovation Map can vary, but a minimum of 2h is suggested to complete all design phases.

4.2.15 S.PSS + DG Design Framework & Cards

Aims
The tool (Emili et al., 2018) can be used to support the generation of ideas on specific aspects of S.PSS applied to DG (network of providers, customer, products and services, offer and payment channel), and to detail out an initial concept idea.

What it consists of
The tool is composed of a Design Framework, a set of Cards and a Design Canvas (Fig. 4.100).

Fig. 4.100 The design framework, design canvas and cards. Source designed by the Authors

The Design Framework
The Design Framework visualises the main elements characterising S.PSS applied to DG models, which are organised in six 'building blocks'. Each building block includes specific elements to be considered in the design, as described below.

(1) Network of providers: It refers to the actors involved in providing the energy solutions, which include private enterprise, technology manufacturer, community, local entrepreneurs, Non-Governmental Organisation (NGO), Cooperative, Micro-Finance Institution (MFI), public and governmental entity and national grid supplier.

(2) Products: It refers to a combination of energy system/s (including renewable
energy sources) and energy-using product/s. **Energy systems** include stand-alone systems (mini kit, individual energy system, charging station) and grid-based systems (isolated and connected mini-grid). Energy systems also include the different types of **renewable energy sources** used for DG: solar, hydropower, biomass, wind or hybrid sources (i.e. combination of different renewables). **Energy-using products** refer to the appliances that can be included in the offer in combination with the energy systems. These might include generators, lanterns, lights and bulbs, battery, phone charger, radio, TV, fan, IT and computer devices, etc.

(3) Services: The service category includes consultancy services (training, financing)
and services provided during or at the end of the product life cycle (installation, maintenance and repair, product upgrade, end-of-life services).

(4) Offer: This building block refers to the different types of S.PSS offer that can be applied to DG models. They are classified into product-oriented (pay-to purchase with training, advice and consultancy services: pay-to-purchase with additional services), use-oriented (pay-to-lease; pay-to-rent/share/pool) and result-oriented S.PSSs (pay-per-energy consumed; pay-per-unit of satisfaction).

(5) Customers: It refers to the type of target customers addressed by the S.PSS solution and includes a mix of individual households, productive activity, local entrepreneurs, public buildings, community, public and governmental entity.

(6) Payment channels: This building block refers to the different ways in which customers pay for the energy solution. It includes cash, credit, mobile payments, scratch cards and energy credit codes, in-kind contribution, fee collection and remote monitoring as an activity supporting payment.

For each building block, the Framework provides a series of questions that should guide the user in the design process. For example, the network of providers building block presents questions like: 'Who are the actors involved in the provision of the energy solution? What are their roles and responsibilities? What partnerships can be established?' (Fig. 4.101).

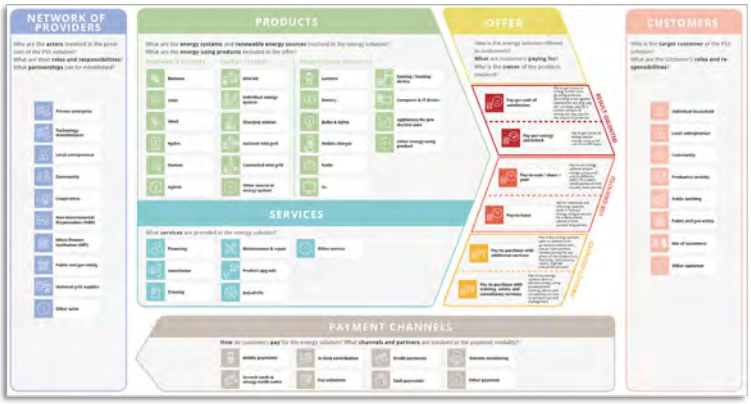


Fig. 4.101 Design framework (Emili et al., 2018)

Cards

The Cards have been developed with the aim of providing support to companies and practitioners in designing the S.PSSs applied to DG. In particular, they collect critical factors, guidelines and successful examples of S.PSS applied to DG in low-income and middle-income contexts. The Cards summarise and organise the existing knowledge developed on S.PSS applied to DG in a clear and meaningful way, so that it can be used to trigger the generation of ideas. These cards are organised according to each building block (Fig. 4.102).

Each set of cards is provided with an Intro Card that specifies what information can be found in there and how to use it. A general structure of the elements contained in the cards is illustrated below (Fig. 4.103).

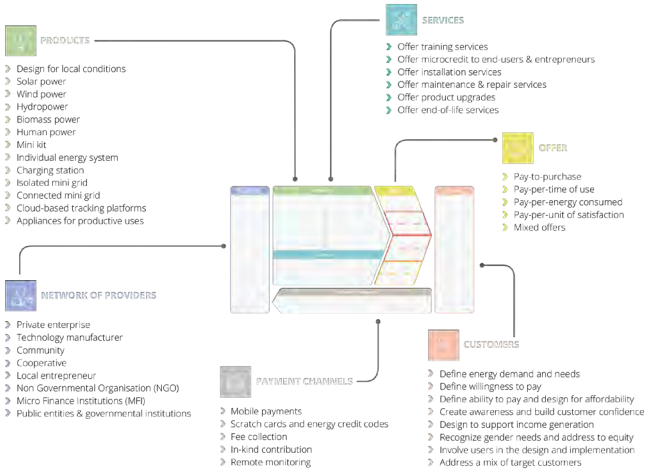


Fig. 4.102 List of cards for each design element (Emili et al., 2018)

Fig. 4.103 Example of cards' structure (Emili et al., 2018)

Design Canvas

Design Canvas is an empty Framework that should be used in the concept generation phase to position post-its and write down ideas. The Canvas follows the same structure as the Design Framework and breaks down S.PSS + DG building blocks into network of providers, products, services, offer, customers and payment channels. It is also provided with some questions to guide the design process (Fig. 4.104).

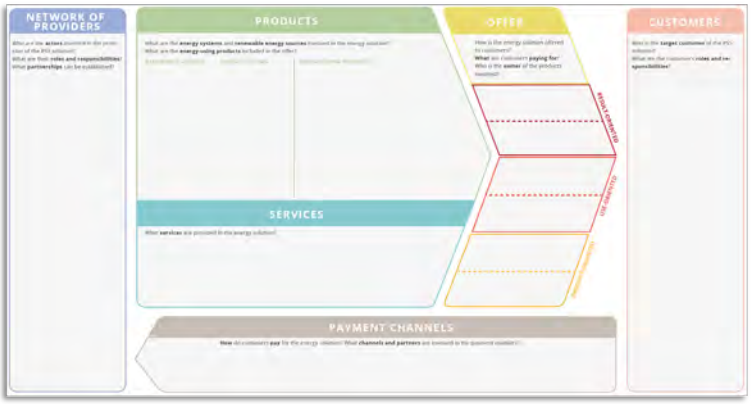


Fig. 4.104 The design canvas (Emili et al., 2018)

Integrating the tool into the design process

Exploring opportunities

Generate ideas

The tool can be used in the beginning of the Exploring opportunities stage to support brainstorming sessions to generate ideas on the various building blocks of the Design Framework. In other words, the tool can be used when there is not any agreed concept direction, to inspire idea generation while looking at the various aspects of S.PSS applied to DG. Ideas then can be reviewed, selected and combined to develop initial concept directions. The idea generation process does not have to follow a specific order; it is possible to start from any building block.

System Concept Design

Detail initial concepts

The main application of the Design Framework and Cards

is the detailing of an initial concept idea. In fact, the tool allows to go in-depth in all the building blocks and to generate ideas for each of them. This activity can be carried out after having used the Innovation Map to generate an idea, or if the designer/s already has a draft idea of the business model they would like to detail. After the idea generation, ideas are reviewed to select the most promising ones to be transformed into a detailed concept design.

Improve specific aspects of an existing solution
The tool can also be applied to brainstorm on a specific aspect of an existing S.PSS solution. For example, a company that is already delivering a S.PSS solution may want to improve the payment modality, and they can use the tool focusing only on the Payment Channels building block to get inspired by the guidelines, case studies and suggestions (Fig. 4.105).

It is not required to follow a specific order while using the tool for idea generation. Users are encouraged to decide the starting point they prefer. The design process can be, therefore, carried out in an unstructured way. For example, one can begin with browsing Cards and using the Framework as a reference, and then writing down ideas on post-its, positioning them on the Canvas.

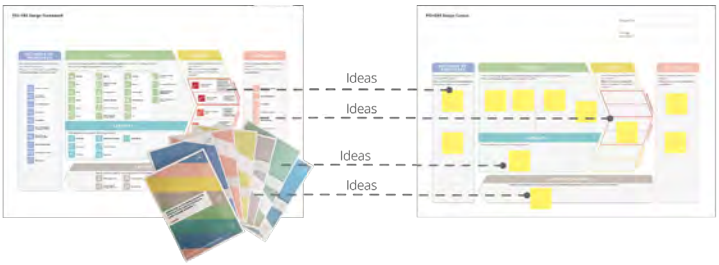


Fig. 4.105 Positioning ideas on the design canvas

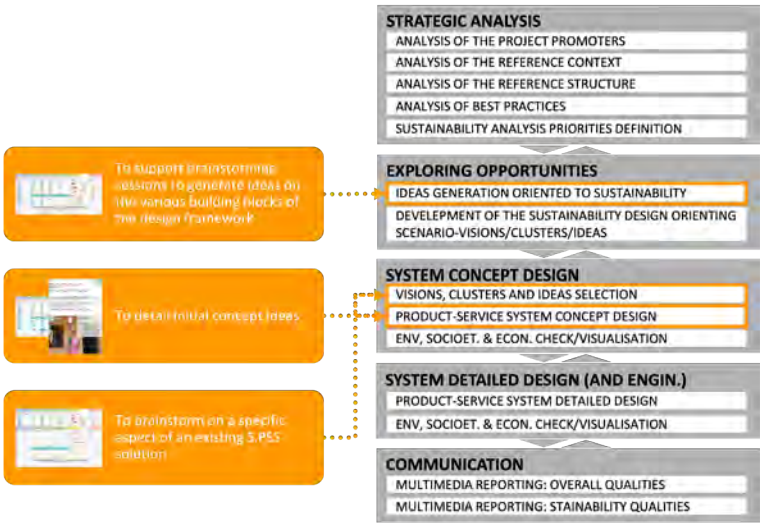


Fig. 4.106 S.PSS + DG Design Framework & Cards' integration into the MSDS design process

Results

At the end of the design process, all elements of S.PSS applied to DG should be detailed with selected ideas (among the ones generated in the activity), and the questions provided on the Canvas should be answered. The tool can be used in combination with other tools and resources. In fact, concepts generated with the tool might require further evaluation in terms of financial sustainability, technical feasibility, presence of appropriate regulations and other external factors.

How to use the tool

The Design Framework and Cards have been developed to be flexibly applied according to users' needs. In particular, the applications for the tool could be:

- To start-up a new business: to support the design and detailing of new business models from scratch.
- To refine and reorient existing solutions: the tool can be used to focus on specific aspects of an existing business model. For example, a company might already have an offer in place but may want to improve aspects related

to the payment channel.

This section illustrates how the Design Framework and Cards can be integrated in the SD4SEA design process and what outcomes can arise from its application.

Availability and resources required
The tool is available for a free download at www.lenses.polimi.it and on www.se4alldesigntoolkit.com. The tool has been designed to be used in workshops and (co)design sessions, therefore a printed format is preferable. /The Design Framework should at least be A2, the Design Canvas can be printed in A1 and the Cards can be printed on A4 and folded.

To use the Design Framework and Cards, we suggest a minimum of 2h to grasp the most essential aspects; and an addition of 8h to go in-depth and detail every building block. We also suggest that the idea generation is carried out in multidisciplinary teams to maximise the innovation potential.

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