

SYSTEM DESIGN FOR SUSTAINABILITY IN PRACTICE

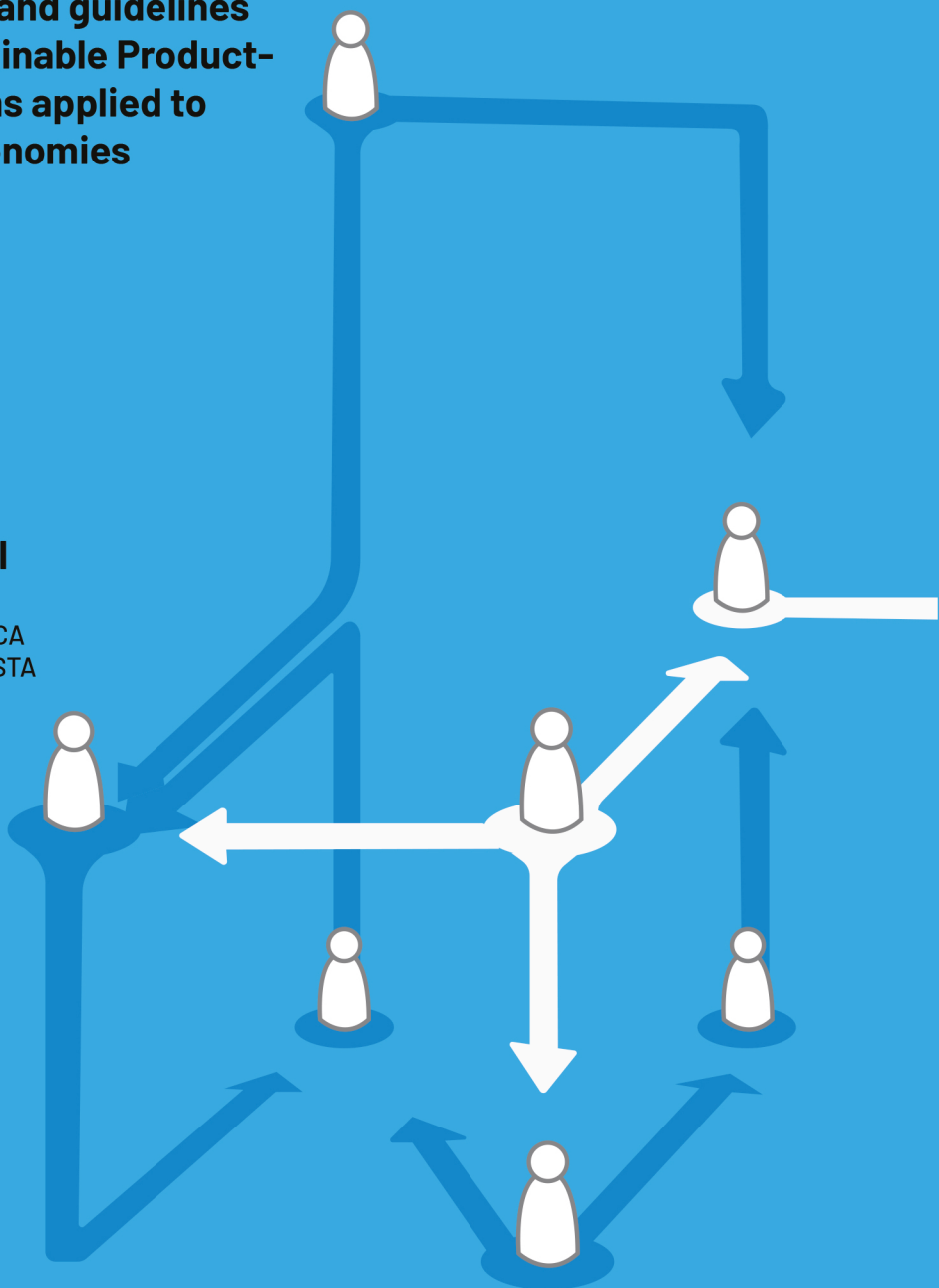
**Methods, tools and guidelines
to design Sustainable Product-
Service Systems applied to
Distributed Economies**

Second Edition

CARLO VEZZOLI

WITH HANG SU,
ALESSANDRA PETRECCA
AND GABRIELE TEMPESTA

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*Carlo Vezzoli
with Hang Su, Alessandra Petrecca and Gabriele Tempesta*

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IN PRACTICE**

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

Second Edition

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*Biblion Edizioni S.r.l
Via G. Govone, 70
20155 Milano
Telefono Fisso +39 02/27019690
Mobile +39 339/2134520*

Carlo Vezzoli
with Hang Su, Alessandra
Petrecca, and Gabriele Tempesta

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Layout and paging: **Fenia Capobianco, Noortieni Khairulisa, Ning Meng, Gabriele Rabbito and Roberto Russo.**

Graphic layout: **Roberta Sironi**

Cover design: **Mauro Alex Rego**

English revision: **Prathana Shah and Gabriele Tempesta**

Note on the Second Edition

Chapter 1 has been updated to reflect the current sustainability context, with revised statistical data, policy references and illustrative examples. Chapters 3.1, 3.2 and 3.3 have been substantially revised, with obsolete case studies removed, existing examples updated, and numerous new international examples introduced. Chapter 4.2.1 has also been substantially expanded through the introduction of a new Miro-based digital toolkit supporting the MSDS method.

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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 enter-

prises/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 stakeholders' 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 *LeNS³, 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

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

the European Union, 5^o 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 (SD4SEA) focused on Sustainable Product-Service System applied to Distributed Renewable Energies (DRE)*, funded by the European Union Edulink program (Europe and Africa). (4) *LeNSin: The Learning Network of Networks on Sustainability, a Multipolar and open network of networks for curricula development on Design for Sustainability, focused on Sustainable Product-Service Systems (S.PSS) applied to Distributed Economies (DE)*, funded by the European Union Erasmus+ program.

1.1 Sustainable development and system
innovation

1.2 Evolution of design for sustainability

1.1

Sustainable development and system innovation

4 Resilience is the capacity of an ecosystem to overcome certain disturbances without losing irrevocably the conditions for its equilibrium. This concept, extended planet-wide, introduces the idea that the ecosystem 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.

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;

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.

- 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.

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 Millennium 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 sustaina-

ble 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 contexts, 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 represent sustainability with three inter-linked 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. Fig. 1.3 (Schindler & Starr, 2024) shows the annual Arctic sea ice minimum in 1979 and in 2024. As one of the consequences, several areas of land would be submerged below water level (Seneviratne et al., 2021).

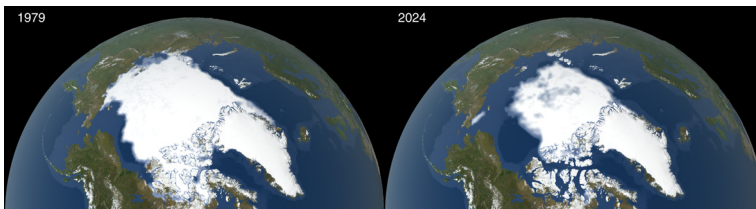


Fig. 1.3 Reduction in Arctic sea ice minimum extent from 1979 to 2024, illustrating one of the severe consequences of global warming. NASA/Goddard Space Flight Center Scientific Visualization Studio; Blue Marble data courtesy of Reto Stöckli (NASA/GSFC).

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 (see Fig. 1.4). Furthermore, recent projections by IPCC show that the frequency of such events is likely to keep increasing in the next century, depending on different scenarios related to climate change (IPCC, 2021). However, climate change is not the only environmental damage caused by humankind. Other significant issues must also be considered.

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

Global reported natural disasters by type, 1970 to 2025

The annual reported number of natural disasters, categorized by type. Note that this largely reflects increases in data reporting, and should not be used to assess the total number of events.

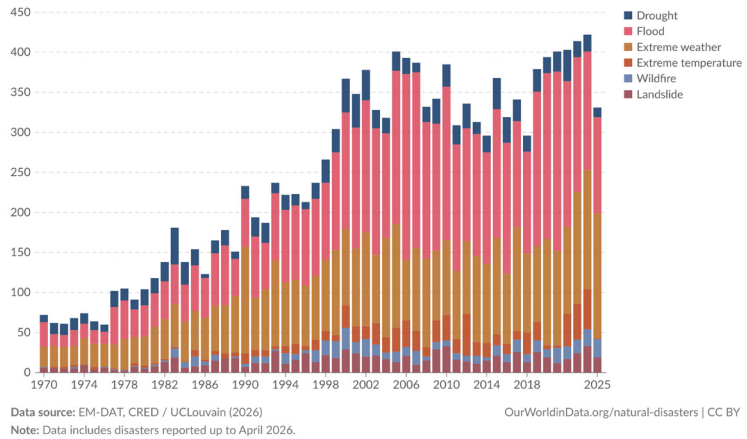


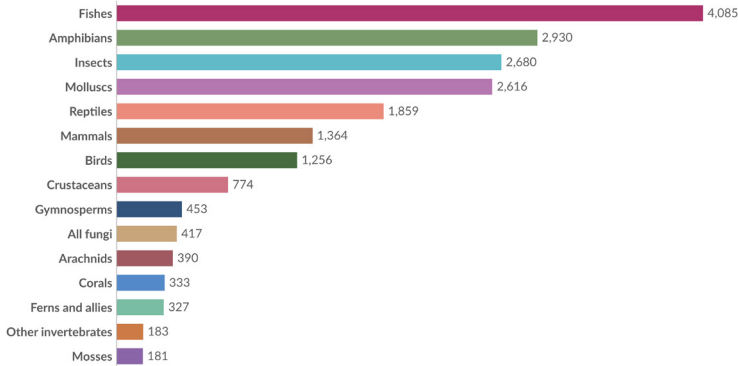
Fig. 1.4 EM-DAT, CRED / UCLouvain (2026) – with major processing by Our World in Data

One major issue is air pollution, including fine particulate matter (PM_{2.5}), ozone (O₃), nitrogen dioxide (NO₂), sulphur dioxide (SO₂), carbon monoxide (CO) and other pollutants, generated largely by transport, industry, energy production, agriculture, waste management and household fuel combustion. The World Health Organization estimates that the combined effects of ambient and household air pollution are associated with 6.7 million premature deaths annually worldwide (World Health Organization, 2024a, 2024b, 2025). Production and consumption systems also have a large impact on the extinction of various species. The health of the 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 around 1 million animal and plant species are threatened with extinction, more than ever before in human history. This risk is also reflected in the IUCN Red List data (see Fig. 1.5). Current responses are rendered insufficient and truly transformative changes are needed to restore the ecosystems. Furthermore, the quantity of waste generated by human activities keeps increasing at a higher rate.

Number of species threatened with extinction

The IUCN Red List has assessed the extinction risk¹ of only a small share of the total known species in the world. This means the number of species threatened with extinction is likely to be a significant underestimate of the total number of species at risk.

Our World
in Data



Data source: International Union for Conservation of Nature Red List of Threatened Species (2025) | OurWorldinData.org/biodiversity | CC BY
 Note: 'Threatened' species are those that are categorized as 'Critically endangered', 'Endangered' or 'Vulnerable' on the IUCN Red List.

Fig. 1.5 International Union for Conservation of Nature Red List of Threatened Species (2025) – with minor processing by Our World in Data

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 5 kg 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 2026, *Earth Overshoot Day*, i.e. the date on which humanity's resource consumption for the year exceeds Earth's capacity to regenerate those resources in the same year, fell on 30 July (Global Footprint Network, 2026). According to the Global Footprint Network's dates, Earth Overshoot Day has moved from the end of December in the early 1970s to 30 July in 2026, showing that humanity is using Earth's regenerative capacity increasingly earlier in the year. In fact, some countries have a greater contribution than others;

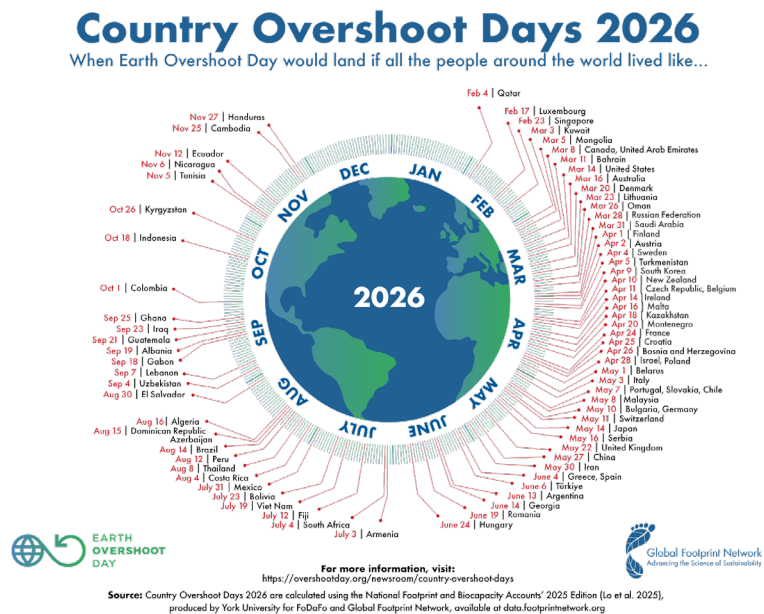


Fig. 1.6 Earth Overshoot Days in some countries in 2026 (Global Footprint Network, 2026)

Fig. 1.6 shows when Earth Overshoot Day would occur if the world population lived like in many representative countries.

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 damage* 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 toxicity 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

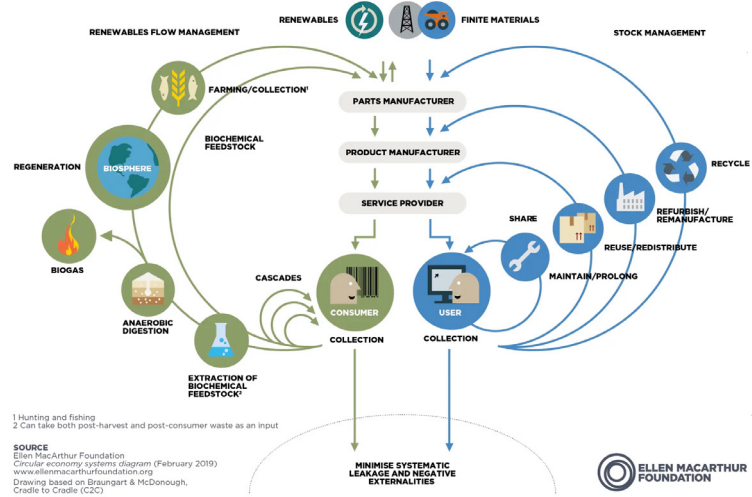


Fig. 1.7 The Circular Economy diagram representing biological and technical cycles (Ellen MacArthur Foundation, 2019)

at the end of their use, while minimising the generation of waste" (European Commission, 2020).

Finally, we can imagine the scenario of the demand for well-being, **dematerialisation**, 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):

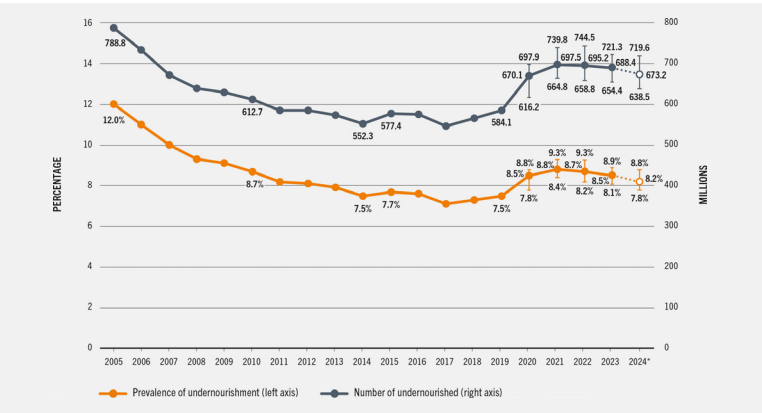
- Eradicate poverty and hunger in all its forms everywhere (SDG 1, 2);
- Ensure healthy lives and promote well-being for all at all ages (SDG 3);
- Ensure inclusive and equitable quality education for all (SDG 4);
- Achieve gender equality and empower all women and girls (SDG 5);
- Ensure access to energy, water and sanitation for all (SDG 6, 7);
- Reduce inequality within and among countries (see SDG 10);
- Promote just, peaceful and inclusive societies (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 2025* (FAO et al., 2025) states that, “Between 638 and 720 million people faced hunger in 2024. Considering the point estimate 673 million, this indicates a decrease of 15 million people compared to 2023 and 22 million compared to 2022.” (see Fig. 1.8).



8 The State of Food Security and Nutrition in the World 2025

Fig. 1.8 Undernourishment in the World from 2005 and estimated rates for 2024 (FAO et al., 2025)⁸

These numbers on global hunger remain alarmingly high, with a significant proportion of the population still affected, particularly in low- and middle-income contexts. According to the most recent FAO report (2025), hunger continues to rise in Africa, where approximately one in five people is affected. In Asia, levels of undernourishment have remained relatively stable, showing no substantial improvement or deterioration in recent years. In contrast, some positive developments can be observed in Latin America and the Caribbean, where gradual progress has been made in reducing hunger levels. Overall, despite regional differences, the global situation remains critical and highlights the persistence of structural inequalities in access to food security.

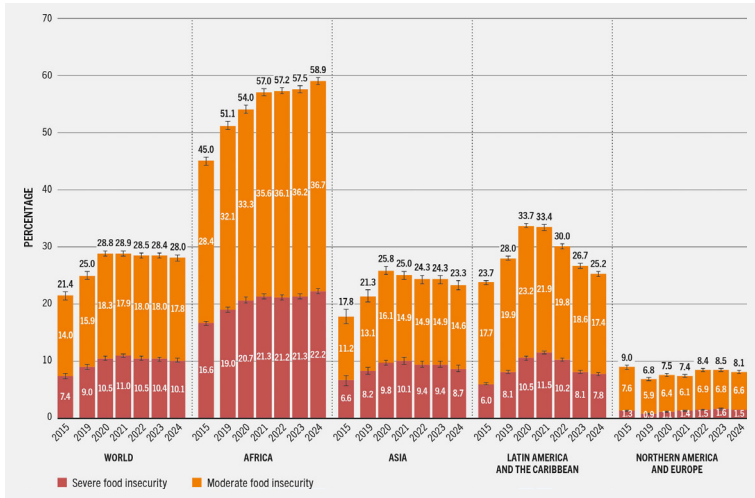


Fig. 1.9 Global undernourished population by different continent of the world (FAO et al., 2025)

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**, especially those that currently have only a 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 today¹⁰.

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 ecosystems.

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

10 On this issue see works by the Wuppertal Institut für Klima, Umwelt, Energie; 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).

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 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 Economies¹² appear as promising to couple environmental, socio-ethical 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.

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).

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 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;

14 Life Cycle Assessment ‘addresses the environmental aspects and potential environmental impacts 2) (e.g. use of resources and environmental consequences of emissions) 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).

2) the functional approach: to design and evaluate a product's environmental sustainability, 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 (BoP¹⁵)*, i.e. the social aspects of sustainability.

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 or-

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.

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 scale 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 socio-ethical 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.

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

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

2.3 Designing S.PSS applied to 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 incentivised 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.,

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*.

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 DE¹⁶. 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.

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 them¹⁷), when designing new Product-Service Systems (with the potentialities to be radically sustainable), that would steer it towards an environmentally, socio-ethically and economically sustainable solutions.

17 See chapter 4

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

The next chapter presents the strategies, the guidelines¹⁸ and some examples to orient the design towards:

- Environmentally sustainable PSS;
- Socio-ethically sustainable PSS;
- S.PSS applied to DE.

3.1 Strategies, guidelines and examples to design environmentally sustainable PSS

3.2 Strategies, guidelines and examples to design socially sustainable PSS

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

3.1 Strategies, guidelines and examples to design environmentally sustainable PSS

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).

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.

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.

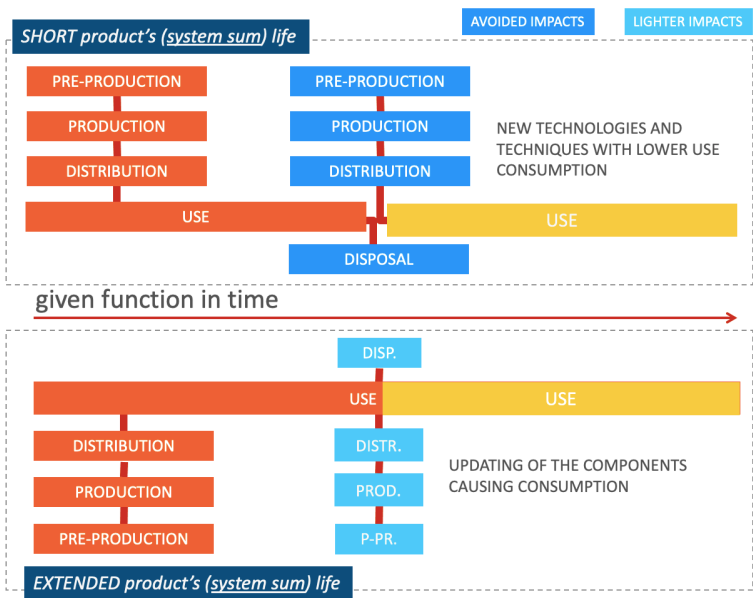


Fig. 3.1 Environmental advantages of a product (system sum) with a longer lifespan

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.

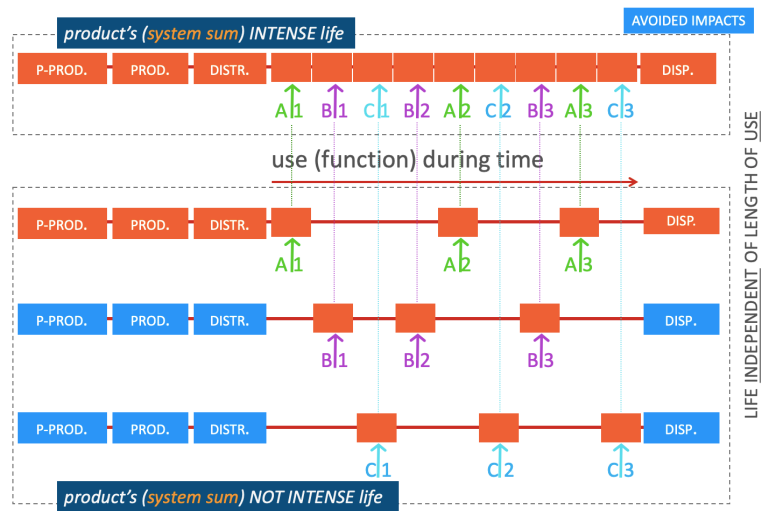


Fig. 3.2 Environmental advantages of intensifying the usage of the product's system sum (lifespan not dependent on the length of use)

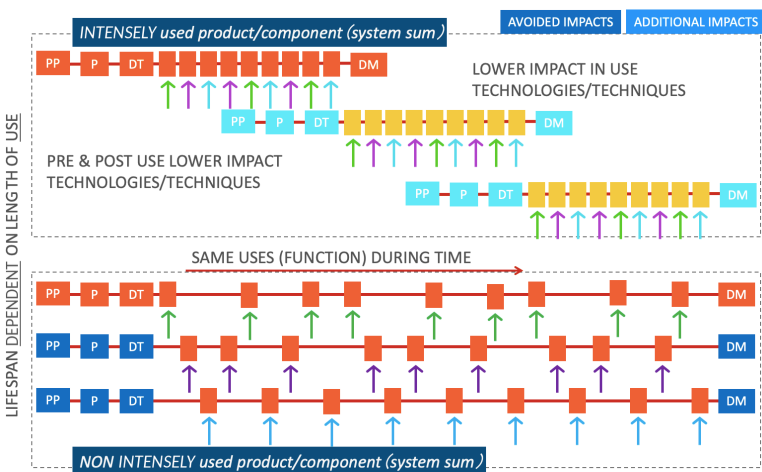


Fig. 3.3 Environmental advantages of intensifying the usage at home of the product (lifespan dependent by the length of use)

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)?
- Could the system stop working (or degrade critically) if external digital services or network connectivity that it relies on become unavailable (e.g., phase-out of cloud services, API/SDK licenses of digital services)?
- Is there a mismatch between the digital and physical components' lifespans that shortens the system's durability (e.g., refreshes or feature drops / obsolescence)?

Guidelines for system life optimisation

- Complement products or infrastructures with services for maintenance, repair, substitution, etc., delivered via human or digital means (e.g., remote trouble shooting services), included in the purchase price. **examples 1**
- Complement products or infrastructures with services for technological upgrades, delivered via human or digital means (e.g., software / firmware updates or instructions for self-managed upgrades), included in the purchase price. **examples 2**

- Complement products or infrastructures with services for aesthetical / cultural upgrades, delivered via human or digital means (e.g., digital interface refreshes or style adaptations), included in the purchase price.
- Complement products or infrastructures with services enabling their reconfiguration, adaptation and flexibility (e.g., for changing context or location), supported by human or digital means where appropriate. **examples 3**
- Complement products or infrastructures with all-inclusive take-back services aimed at re-use or re-manufacturing, delivered via human and digital means (e.g., digital tracking / incentive and communication channels) where appropriate. **examples 4**
- Offer services for the shared use of ownerless products or infrastructures with pay-per-unit, where appropriate facilitated by digital platforms / services for customers (e.g., booking, access control, and usage optimization). **examples 5**
- Offer services for the shared ownership (i.e., collective purchase) of products or infrastructures, where appropriate facilitated by digital platforms (e.g., for group coordination, identity verification, and usage management).
- Offer services for the sharing and/or exchange of products, facilitated by digital platform services where appropriate. **examples 6**
- Offer either physical infrastructure or digital platform services for product reuse or second-hand sales (e.g., collection points, product cleaning or online marketplace for used products). **examples 7**

Examples

1.1 Repairable chair with long warranty - Herman Miller



Fig. 3.4 Left: Aeron chair; Middle and right: Easily assembly and disassembly based on four screws and a single screwdriver²⁰

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 printing - 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, re-use. In particular, 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

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. Updatable washing machine - 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 database 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.

3.1 Furniture take-back service - Rype Office

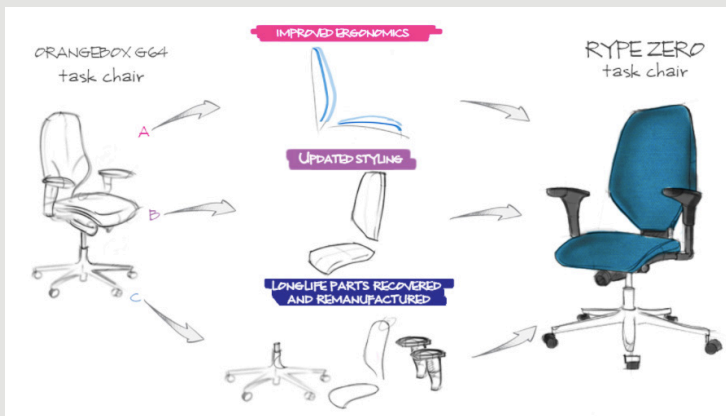


Fig. 3.5 Development process after taking back furniture²¹

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.

²¹ Rype office (2022). Available at: <https://www.rypeoffice.com/rype-zero/>

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 work-spaces, 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.

3.2 Virtual livestock fencing - Vence

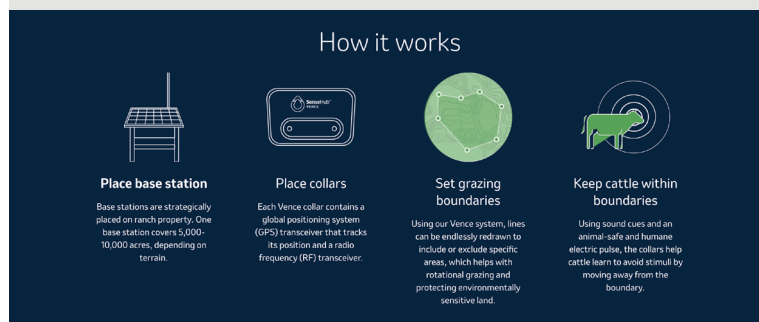


Fig. 3.6 Vence virtual fencing: device and software²²

Vence, now part of Merck Animal Health, offers a virtual fencing system for livestock management, allowing cattle or sheep to be controlled and monitored through virtual fences instead of traditional physical barriers. The offer integrates a smart mobile-device ecosystem, which includes the Electronic Collar, a wearable device equipped with GPS and RF transceivers for tracking and for guiding cattle through sound cues and a controlled electric pulse to keep animals within designated virtual boundaries; the Base Station, a solar-powered data-communication

²² Merck Animal Health (2026). Available at: <https://www.merck-animal-health-usa.com/hub/vence/>. Used with permission for educational, non-commercial purposes.

unit; and the Vence system, a software platform that allows customers to set and modify virtual fence lines and monitor herd movement using a smartphone, tablet or computer. Vence provides the system to individual and business customers with support services, including installation, training, maintenance and repair, and replacement where included in the contract. These services help maintain system performance over time and make the solution adaptable to different geographical locations and grazing contexts, as virtual fence areas can be reset. The model may also contribute to environmental benefits by reducing the resource need for physical grazing infrastructure and supporting more flexible grazing management.

4. Carpet-tile leasing - Desso

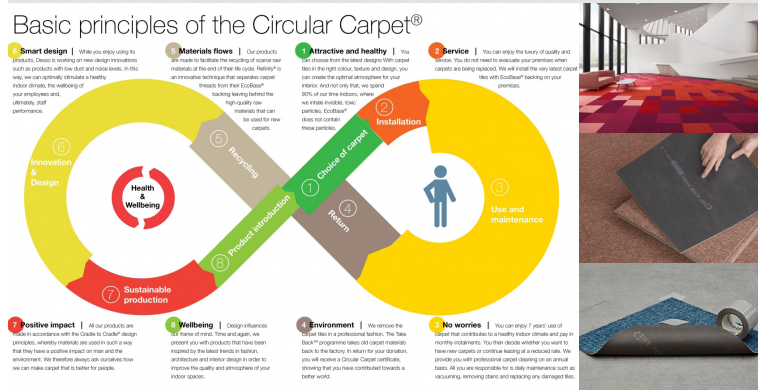


Fig. 3.7 Top Left: typical Desso modular design²³, Middle: sample of modular tiles²⁴ Right: sample of tile sticking technology to facilitate punctual maintenance²⁵; bottom: Circular carpet process implemented by Desso²⁶

DESSO, now a Tarkett brand, offers carpets and carpet tiles for commercial customers across different sectors. Among its earlier sustainable solutions, it developed the Carpet Tile Leasing Service, which reframed carpet tiles as a service rather than a one-off product: DESSO retained ownership and provided installation,

23 Tarkett (2022). Available at: https://www.archiproducts.com/en/products/tarkett/carpet-tiles-desso-palatin_266044.

24 Tarkett (2022). Available at: https://professionals.tarkett.com/en_EU/node/desso-carpet-tile-and-roll-solutions-innovation-functionality-and-sustainability-5527

25 Tarkett (2022). Available at: https://professionals.tarkett.com/en_EU/node/tarketttape-easy-quick-and-clean-installation-of-carpet-tiles-5193

26 Tarkett (2022). Available at: <https://www.brandstory.nl/work/circular-carpet-lease-concept/>

cleaning, maintenance and eventual removal. After the standard seven-year contract, a new carpet was supplied, while the previous one was collected, recycled and reintroduced into a new production cycle.

This model relied on a design approach focused on maintenance and repair, supporting the extension of lifetime of the flooring system. Unlike carpet rolls, tiles are modular and easy to handle: each tile is fixed with tape and can be removed individually, avoiding the need to replace the entire floor when only specific areas are worn or damaged. Because DESSO did not simply sell the tiles, it remained responsible for upkeep and replacement, ensuring consistent performance over time.

Resource use across pre-production, manufacturing and disposal was reduced through this approach. Products were designed for recycling and regeneration, supporting repeated material use. By retaining control over the product and its end-of-life phase, DESSO could also defer or reduce costs associated with producing and distributing new materials, while limiting expenses linked to landfill and raw material supply.

5.1. Free-floating bike sharing - Ridemovi



Fig. 3.8 Left: bike²⁷; right: interaction through the app²⁸

²⁷ RideMovi (2022). Available at: <https://www.ridemovi.com/press-en/>

²⁸ Ridemovi (2022). Available at: <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. Shared office services - YoRoom Milano



Fig. 3.9 Overview of YoRoom shared spaces and facilities²⁹

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

²⁹ YoRoom (2022).

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. Shared wardrobe service - EGO

EGO was an Italian company offering a shared-clothing system for a closed group of women. After subscribing, each user selected 14 garments from a sample book to be included in the “shared wardrobe”. Once a week, the user went to the point of sale, chose and collected seven garments, and re-



Fig. 3.10 Left: EGO service process; Right: EGO physical store³⁰

turned the clothes used during the previous week. EGO took care of washing and maintaining the garments. The company not only managed the service, but also designed the clothes and outsourced their manufacture to Italian companies.

In the traditional production and consumption model, a clothing producer sells garments to users. In this case, product ownership changed: the producer continued to own the clothes and became the provider of a rental service, while users rented clothes instead of buying them. The main environmental benefit came from intensifying the use of clothes, meaning that fewer garments were needed in a given context to meet a given demand for clean clothes (system life optimisation through use intensification). In addition, since the producer-provider owned the clothes, it had an economic interest in extending their life span, in order to postpone maintenance, disposal and replacement costs (system life optimisation through product life extension).

As a consequence of system life optimisation, resource consumption could be reduced in terms of the materials and energy used to produce, transport and dispose of clothes. Washing was also carried out with high-efficiency washing machines, since EGO was incentivised to reduce the cost of each wash and therefore the amount of energy and deter-

³⁰ EGO il Guardaroba (2019). Available at: <https://www.facebook.com/EGOita/>

gent used. However, compared with the traditional situation in which users own and wash their clothes, the EGO system could involve a higher number of washes, because garments were washed after a single use.

Although EGO was distinctive because the clothing producer retained ownership and designed the garments specifically for shared use, similar shared-wardrobe models continue today through rental-subscription platforms such as Le Closet and Rent the Runway.

6.1 Neighbourhood goods sharing - Peerby



Fig. 3.11 Top: Peerby goods sharing; Bottom: Peerby app³¹

³¹ Peerby (2022). Available at: <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 replacement 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 Bag-swapping platform - Freitag S.W.A.P

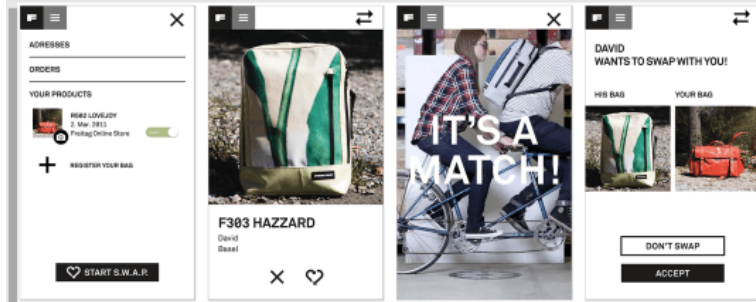


Fig. 3.12 Freitag S.W.A.P online platform³²

³² Freitag (2019)
Available at: <https://www.fastcompany.com/90415930/freitag-s-new-antishop-lets-you-trade-backpacks-instead-of-buying-a-new-one>

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.

7. Furniture rental platform - Roomii

Roomii is an online platform for renting, and also facilitating the buying and selling of pre-owned premium furniture, allowing furniture to be kept in use for longer

cycles. Consumers can rent furniture for different periods, such as one month, three months, six months or one year, and may continue month by month after the first year. Roomii supports the process for users, from listing and reviewing furniture to coordinating pick-up, delivery and payment, so that good furniture does not go to waste. The furniture is mainly sourced from local owners, who can list items for rent or sale, or sell them directly to Roomii where this option is available. When Roomii receives a furniture listing or selling request, the item is reviewed, its condition is checked, and the platform helps make it available through its online marketplace. Roomii therefore offers a digital platform service for furniture reuse, with a strong emphasis on peer-to-peer rental alongside second-hand selling. It is economically attractive for Roomii and furniture owners to extend the lifespan of furniture through repeated rental and continued use.

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 the service fully used?- Does the system lack remote digital solutions (e.g., tele assistance, video communication, remote monitoring and control or software updates) that could reduce or replace the physical transport of people, goods, or semi-finished products?

Guidelines for transportation/distribution reduction

- Complement the product or infrastructure with remote services or digital channels that provide support and guidance throughout the lifecycle (e.g., purchase, maintenance, repair, upgrade), included in the purchase price. **example 1**
- The producer/provider creates partnerships with locally-based service providers offering all-inclusive maintenance, repair, upgrade, end-of-life collection/valorization, etc., managed or coordinated via human or digital means (e.g., digital platform services).
- The producer/provider creates partnerships with locally-based reputable suppliers of resources (material and energy) for the product or infrastructure pre-production, production and care. **example 2**
- The developer/designer creates partnerships with product/infrastructure manufacturers for local production and delivery, where appropriate facilitated by digital means (e.g., digital files/instructions sent to decentralized manufacturers network)
- Complement the product or infrastructure with services for on-site assembly delivered via human support or digital means (e.g., digital instructions), included in the purchase price. **example 3**
- The producer/provider creates partnerships with retailers and other stakeholders to reduce/avoid packaging (tertiary, secondary or primary). **example 4**
- The producer/provider creates partnerships (e.g., with component suppliers and manufacturers) to reduce or avoid transportation/packaging of semi-finished products.
- Complement the products or semi-finished

products with service for their optimized distribution (facilitated by digital means where appropriate), included in the purchase price.

- Offer products with reusable/returnable packaging, managed via human or digital means where applicable, e.g., tracking, scheduling.

example 5

- Offer digitally remote support and status monitoring of activities and interventions carried out on-site by the user, e.g., maintenance, repair, upgrade, end-of-life collection/valorisation.
- The producer/provider creates partnerships for optimized multi-modal transportation solutions facilitated by digital platforms where appropriate.

Examples

1. Repair and reuse services - Patagonia Worn Wear



Fig. 3.13 Patagonia's Worn Wear repair station³³

If a Patagonia product rips or tears, alternatively to the option where customers return products to Pata-

³³ Patagonia (2022). Available at: <https://popupcity.net/observations/patagonia-opens-store-that-sells-repaired-clothes-only/>

gonia 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 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 Direct-to-consumer knitwear - Artknit Studios

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

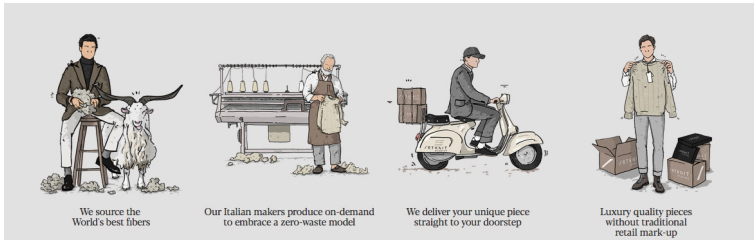


Fig. 3.14 Artknit logistic model, based on the delivery directly from manufacturers³⁴

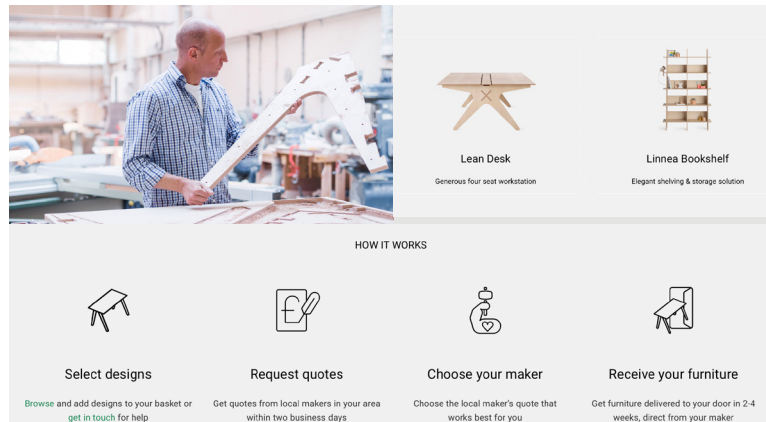
can find details of the material and the manufacturer of their items.

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 furniture manufacturing - OpenDesk

“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

³⁴ Artknit (2022). Available at: <https://www.doingitaly.com/blog/artknit-studios-zero-waste-italian-luxury-champions-region-al-artisans-sustainability>



35 OpenDesk (2022).
Available at: [https://
www.opendesk.cc/](https://www.opendesk.cc/)

Fig. 3.15 Top-left: OpenDesk product manufacturing made by local workshops; Top-right: OpenDesk product design sample; Bottom: OpenDesk service stages³⁵

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. Flat-pack home assembly - IKEA

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. Low-packaging retail - Negozio Leggero



Fig. 3.16 Containers to get goods “on tap” in Negozio Leggero³⁶

Negozio Leggero is a chain of 20 small shops in Italy, France, Switzerland, as well as an 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 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

³⁶ Negozio Leggero (2022). Available at: <https://www.negoziolleggero.it/franchising/>

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* decided 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.

5. Reusable smart packaging - LivingPackets



Fig. 3.17 Smart boxes and app³⁷

³⁷ Living Packets Press (2026). Available at: <https://livingpackets.com/press>. Used with permission for educational, non-commercial purposes.

LivingPackets offers a Packaging-as-a-Service model that revolutionizes e-commerce logistics through reusable smart packaging boxes and associated digital services. Customers pay solely for the all-inclusive delivery service, without concern for the preparation, maintenance, or recycling of packaging materials. Company staff collect goods directly from the cus-

tomers' location and handle the packaging process on site. Each smart box is designed for repeated use (up to 1,000 cycles) and eventual recycling, being equipped with monitoring sensors, GPS tracking, a secure locking mechanism, a built-in scale, an internal camera and/or an e-ink display. Through a dedicated mobile application, both individual or business clients can manage shipments, monitor real-time location and conditions of the contents, and ensure the security and traceability of each delivery.

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?

Does the system lack digital solutions (e.g., automation, smart monitoring) that could reduce resource consumption?

Guidelines for resources reduction

- Complement the supply of resources/semi-finished products/consumables related to the product or infrastructure system with services for their optimal use (facilitated by digital means where appropriate), included in the purchase price. **example 1**
- Offer access to products or infrastructures (enabling platform; facilitated by digital means where appropriate) through payment based on the unit of satisfaction. **example 2**
- Offer access to products or infrastructures (enabling platform; facilitated by digital means where appropriate) through payment based on a fixed fee per given period of time. **example 3**
- Offer full-service (final result; facilitated by digital means where appropriate) to client/final user through payment based on the unit of satisfaction. **example 4**
- Provide resource saving technologies and practices to upgrade equipment where the investment is financed through subsequent resource savings. **example 5**
- Offer collective use of products or infrastructures, coordinated and optimized through digital platforms where appropriate. **example 6**
- Outsource and/or offer activities when higher specialisation and technological efficiency of products or infrastructures are available. **example 7**

- Create partnerships to use/integrate existing products or infrastructures. **example 8**
- Complement the product or infrastructure offer with services designed for their adaptation in the context of use (facilitated by digital where appropriate) aimed at resource optimization, included in the purchase price. **example 9**
- Complement product or infrastructure with services designed for their adaptation to use in variations of resource requirements, included in the purchase price.
- Offer products/semi-finished products based on availability. **example 10**
- Offer products/semi-finished products on pre-determined demand (facilitated by digital means where appropriate) aimed at avoiding unsold inventory and/or surplus production. **example 11**

Examples

1. Chemical management services - Quaker Houghton

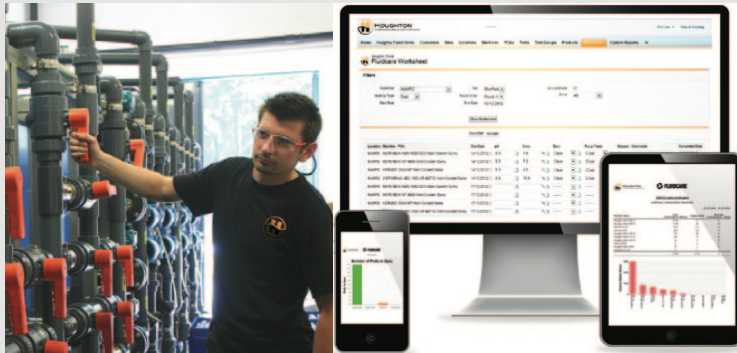


Fig. 3.18 Left: A Quaker Houghton technician checks fluid levels during an inspection. Right: Quaker Houghton's data-driven fluid management system uses proprietary monitoring technologies and software to track, control and optimise fluid performance³⁸

³⁸ Quaker Houghton Fluidcare Chemical Management Service, everything you need for optimal performance, p. 10. Available at: <https://home.quakerhoughton.com>

In the traditional relationship between chemical suppliers and their customers, the supplier makes a profit by maximising the volume of chemicals sold. Chemical management services shift this relationship towards a strategic alliance between the chemical supplier and the customer. Instead of only purchasing chemicals, the customer buys chemical management services.

The chemical provider takes a direct role in managing the customer's chemicals throughout their life cycle, including purchasing, monitoring, handling, use and disposal. This changes the distribution of responsibility for the customer's production processes and the quality of the final products. Houghton, now part of Quaker Houghton, has offered fluid management services in which the company takes responsibility for managing the customer's industrial fluids and lubricants. These services are designed to match the customer's operational demand. The activities included in the management service vary from periodic site visits to operators based permanently at the customer's production site.

The savings gained from fluid management services include both hard and soft savings. Hard savings can be obtained through reductions in the use of fluid-care products and lower disposal costs for discharged lubricants. Soft savings may be obtained by reducing plant downtime and avoiding additional labour costs. Where contracts are based on fixed prices or agreed service outcomes, the provider has an incentive to estimate and control chemical consumption accurately. If production losses occur because of downtime or mismanagement, responsibility depends on the specific contractual arrangement between the provider and the customer.

The environmental benefits of fluid management services are that less lubricant may be used, less fluid needs to be produced, and the volume of lubricant waste can be reduced. This can also reduce associated CO₂ emissions. By managing customers'

lubricants and process fluids, Quaker Houghton can support improvements in environmental performance and help customers meet environmental management requirements, including those associated with ISO 14001.

2. Pay-per-wash warewashing - Winterhalter

Winterhalter is a provider of commercial warewashing solutions. It offers a pay-per-wash payment model, which means that customers are billed only per wash cycle. The price is all-inclusive and can cover the warewasher, tables, racks, detergent, water treatment, service, maintenance, repairs, transport and installation. Users do not purchase, rent or lease the equipment or consumables. Before washing, they log in to the PAY PER WASH portal, select the number of wash cycles and pay for them. During washing, they enter the wash code on the machine display and load the wash-cycle credit. This innovative interaction between Winterhalter and the client encourages the company to provide durable warewashers and resource-saving washing solutions. These include technologies intended to reduce water, electricity and chemical consumption, as well as equipment that can remain in use for longer through service, maintenance and repair. From a product-service-system perspective, the model links Winterhalter's revenue to the continued use and performance of the warewasher, rather than to a one-off equipment sale.

3.1 Ownerless hydrogen vehicle - Riversimple

Riversimple is a small British transport company that has developed hydrogen fuel-cell vehicles and a proposed ownerless mobility model. Rather than selling its cars, Riversimple intends to offer them through subscription agreements. The company keeps own-



Fig. 3.19 Riversimple hydrogen-powered car: design overview from different angles³⁹

³⁹ Riversimple (2022)

ership of the vehicle, while clients pay an all-inclusive monthly fee, expected to cover vehicle use, insurance, fuel, maintenance and repairs. At the end of the contract, Riversimple takes back the vehicle and can keep it in use through further service cycles. Riversimple also aims to build human-scale, profitable operations near the markets it serves, in order to reduce transport costs and create local jobs. Its best-known vehicle, the Rasa, is powered by hydrogen, is very lightweight compared with conventional cars, and is designed to be aerodynamic and efficient.

3.2 E-vehicle sharing - Free2Move

Free2Move is a free-floating and multi-modal mobility system for individual users operating globally. It provides access to a fleet of electric and hybrid vehicles through an all-inclusive life-cycle service package encompassing positioning, maintenance, repair, upgrades, substitution, and end-of-life (EoL) management, while vehicle ownership remains with the provid-

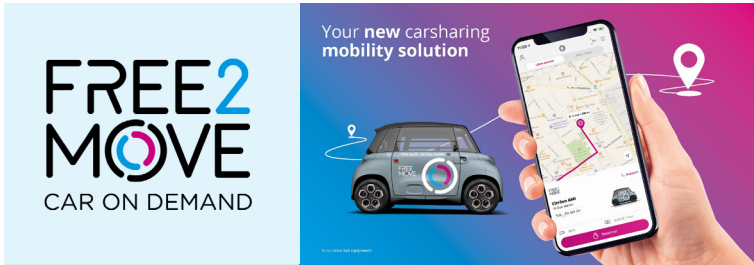


Fig. 3.20 Free2Move e-car with app locating the car⁴⁰

er. Customers can pick up and drop off vehicles within the designated service area and pay only for use—via flexible per-minute, daily, or monthly subscriptions. Users are not required to handle or pay for parking, insurance, charging, or maintenance. A dedicated mobile application integrates all service functions, including reservation, vehicle location, activation, usage, and payment, thereby enhancing convenience and user experience. Because the fleet is owned and managed by the parent automotive group, Stellantis, the company is economically incentivised to design and maintain durable, energy-efficient vehicles that maximize service life and minimize operational costs.

40 Free2Move. Available at: <http://media.stellantis.com/em-en/free2move>. Courtesy of Stellantis.

4. On-demand ride-hailing - DiDi



Fig. 3.21 DIDI app for on-demanding ride matching⁴¹

DiDi provides an app-based, result-oriented mobility service in which users pay per trip for on-demand rides instead of owning or operating (driving) vehicles. The mobile application and digital dispatch platform

41: DiDi (2022). Available at: <https://www.didiglobal.com/news/newsMedia>. Used with permission for educational, not commercial purposes.

match riders and drivers, manage safety features (e.g., SOS alerts, trip-sharing, bilingual chat), process payments, and display real-time trip information. DiDi also encourages shared trips and carpooling through discounted fares, contributing to reduced emissions and more efficient vehicle use. Operating across multiple international markets, DiDi integrates advanced digital capabilities such as routing optimization, precise matching, pooling algorithms, and electric vehicle (EV) integration to lower per-capita emissions compared with private car ownership or non-electric rides, while improving overall vehicle utilization.

5. Energy-savings performance contract - TAC Energy

Energy Service Companies (ESCOs) in Europe and the United States have supplied turnkey service packages comprising energy-resource supply, identification and selection of conservation measures, installation, operation and maintenance of energy systems. ESCO projects have often reported substantial energy savings, in some cases around 30–40%. In this sense, they can be understood as selling thermal comfort rather than fuels.

TAC Energy Solutions was an ESCO providing energy-efficiency and other value-added services, with performance contracting as a core part of its business. It supplied energy-saving technologies and practices to upgrade existing equipment and reduce maintenance costs. In the project considered here, TAC Energy Solutions, then a major company in building automation, was the provider, while Regionfastigheter, one of the largest building administrators in Sweden, was the customer.

The project focused on energy-efficiency retrofits and refurbishments in three hospital areas in the Skåne region. It involved 11 buildings: one university hospi-

tal, five hospitals and five office buildings. The project included air-handling retrofits; installation of heat recovery; rebuilding of heating and cooling systems; updated control systems and water-saving measures; new metering, energy statistics and follow-up structures; and targeted training for administrative and managerial staff.

The principal idea behind the project was that a large part of the investment was financed through realised energy savings. TAC guaranteed a certain level of savings. In this case, Regionfastigheter's investment capacity was limited by budget and public-spending constraints, and it was therefore unable to implement already identified energy and operational savings by itself. It needed a provider or partner able to take responsibility for detailed energy analysis, project implementation, financial arrangements and a savings guarantee. TAC Energy Solutions could provide this.

The project started in 2004/2005 and was reported to have produced positive results. Early training and optimisation delivered more savings than expected. The business model proposed by TAC Energy Solutions was eco-efficient because the company's economic interests converged with an interest in optimising resource use. Much of the investment paid by the customer to TAC was financed through realised energy savings. The ESCO model was reported to have resulted in lower energy consumption, clearer coordination within the operational organisation, upgraded technical standards and simpler, more unified solutions.

Similar ESCO and energy-performance-contracting models remain active today, with providers such as Johnson Controls, Ameresco, Schneider Electric and Siemens implementing building-efficiency projects in which investment is linked to guaranteed or measured energy-cost savings.

6.1 Self-service laundry - Ondablu



43 Ondablu, (2022)

Fig. 3.22 Top left: Ondablu washing machines; Top right: the Ondablu hall; Bottom: the interface⁴³

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 Mille-bolle is responsible for the payment of resource consumption (electricity, detergent etc.), they select the most efficient technologies/ product for both washing and drying.

6.2 Collective e-mobility - Tecnobus Gulliver



Fig. 3.23 Gulliver, the electric bus provided by Tecnobus⁴⁴

Products that operate simultaneously with many users and can respond to a greater number of required operations — that is, products for collective use — can reduce both resource consumption and waste production. This can happen for two main reasons: economies of scale and the greater professionalism of trained operators. In the case of collectively used products, it is also easier to adopt technological solutions that improve consumption efficiency during use. These systems are often more expensive and therefore not always accessible for individual use. Transport systems are a relevant example, as they tend to be more efficient when used collectively or as public services. Eco-efficiency can be further increased

⁴⁴ Tecnobus, (2022). Available at: <https://tecnobus.it/prodotti-gulliver/>

when public transport is based on low-impact engines, as in the case of electric buses. Gulliver is an electric minibus produced by Tecnobus for local public transport. Its compact length of around 5.3 metres gives it good manoeuvrability in narrow and crowded streets, especially in historic city centres. Its low-floor configuration improves accessibility for children, older people and passengers with reduced mobility. Current versions are designed for up to around 30 passengers and use an interchangeable battery system, which allows batteries to be replaced quickly and supports intensive operation on short urban routes. The vehicle is quiet in operation and produces no local exhaust emissions.

6.3 Shared power-bank rental - Jiedian



45 Jiedian (2026). Available at: <https://m.jiediankeji.com/>. Used for educational, non-commercial purposes

Fig. 3.24 Detail from Jiedian official website⁴⁵

Jiedian provides on-demand mobile power-bank rentals through a nationwide network of smart cabinets. Users locate a station through a “mini-program” inside WeChat or Alipay, or the Jiedian app, scan a QR code to unlock a power bank, and return it to a compatible cabinet, paying according to the rental duration. The digital platform manages user authentication, device tracking, pricing, billing and large-scale operations

across Chinese cities. The power banks and cabinets are managed by Jiedian, which oversees product development, operation, maintenance and service quality through its platform. By sharing portable batteries instead of requiring each user to purchase their own, the model improves asset utilisation and can reduce the need for individually own a portable battery pack.

6.4 Peer-to-peer car rental - GoMore



Fig. 3.25 GoMore app: unlocking the car via app⁴⁶

GoMore operates an app-based, peer-to-peer car-rental service in which guests book in the app, pay on the platform, and access vehicles keylessly using the GoMore Keyless telematics technology.

For hosts, GoMore supplies and installs the Keyless technology in the vehicle (a monthly subscription applies). The technology integrates with the vehicle's central locking to enable remote lock/unlock and self-service operation, allowing owners to rent out their cars without being physically present. Beyond P2P rentals, GoMore also offers a vehicle leasing service where cars are specifically "born to be shared," enabling users to lease a vehicle and rent it out to offset monthly costs. Rentals transact through the platform so that the platform's insurance and protections apply, with pricing per trip. By facilitating peer-to-peer sharing and integrating vehicle leasing with sharing capabilities, the model lowers the barrier to accessing mobility, reduces the need for private ownership, and helps decrease vehicle idle time and associated resource use.

⁴⁶ GoMore (2026). Available at: <https://go-more.dk/press>. Used for educational, non-commercial purposes

7. Cleaning-cloth rental service - MEWA Wiesbaden



47 MEWA (2022).
Available at: [https://
www.mewa.it/](https://www.mewa.it/)

Fig. 3.26 Top: MEWA core products (industrial cleaning cloths); Bottom-left: container for dirty swabs; Bottom-right: MEWA service stages⁴⁷

MEWA hires out reusable cotton cleaning cloths to customers such as engineering companies, printing plants and repair shops, as well as other industrial and transport-related clients. MEWA encourages its customers to return their soiled cloths rather than dispose of them. The cloths are delivered to customers in safety containers, used, and then placed back in the containers for collection by MEWA. After being washed in MEWA's industrial washing facilities and checked for quality, the cloths are hired out again. Each cloth can complete this cycle up to 50 times. MEWA is not necessarily the cheapest option. Nevertheless, although cheap disposable rags are available on the market, rising disposal costs for heavily soiled cloths, which may count as hazardous waste, make the service an attractive option. MEWA has become a leading provider in the industrial cleaning-cloth sector. Compared with conventional in-house or domestic washing processes, MEWA's large-scale wash process is more efficient, supported by spe-

cialised equipment, dosing and control systems, and trained staff. Furthermore, the company has not only improved its rental service, but also the material cycles involved. Oil and other residues recovered from returned cloths are reused to support energy production, while water and energy are reused several times through cascade processes in the washing and drying stages. After treatment in MEWA's own wastewater systems, the wastewater reaches a high level of purification before being discharged to municipal treatment plants.

8. Peer-to-peer EV charging - Joosup



Fig. 3.27 Joosup app and charging⁴⁸

Joosup delivers a peer-to-peer, app-based EV-charging service in which drivers book and pay for charging sessions at nearby private home or workplace chargers rather than relying solely on public infrastructure. The mobile app and digital platform handle search, communication, booking, access, and payment, enabling charger hosts to monetize their chargers (with no commission) while offering drivers reliable, bookable off-street charging. By optimizing routing and precise host–driver matching, the platform increases utilization of existing assets—creating economic incentives for owners to keep chargers available and well maintained—and, more broadly, supports lower-emission electric mobility by reducing dependence on public charging and alleviating range anxiety.

⁴⁸ Joosup.

Available at: <https://www.joosup.com>

9. Energy-optimised smart cleaning - Roborock

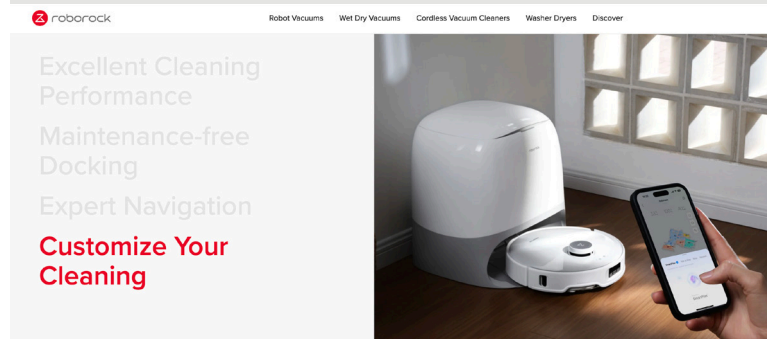


Fig. 3.28 Roborock app to optimise cleaning⁴⁹

⁴⁹ Roborock (2026). Available at: <https://global.roborock.com/>. Used for educational, non-commercial purposes.

Roborock complements its robotic cleaning devices with a bundled, device-linked mobile application. The app pairs with the hardware to support advanced features such as space mapping, real-time cleaning progress monitoring, room-specific scheduling, and adjustable suction/mopping modes, allowing users to tailor functionality to their specific context of use. Beyond basic control, the app enables users to designate “no-go” zones, visualize cleaning paths, and monitor consumable component health. By optimising route planning and enabling targeted cleaning routines, the app enhances operational efficiency, conserves energy, and extends the service life of both consumables and the mechanical hardware itself.

10. Organic produce subscription - 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



Fig. 3.29 Odin farmers at work and service packaging⁵⁰

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.

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

11. Crowdsourced fashion production - Gustin

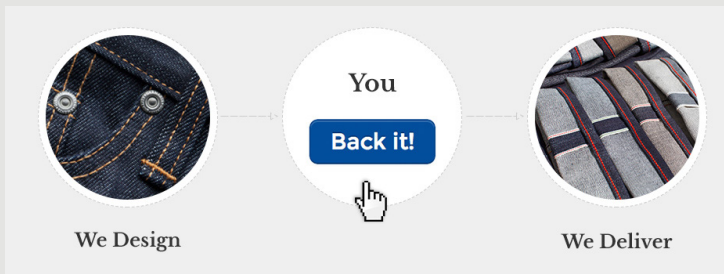


Fig. 3.30 The way Gustin do crowdsourced⁵¹

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 cus-

51 Gustin, (2022). Available at: <https://www.weargustin.com/howitworks>

customer's needs. This is done by customers pre-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.

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

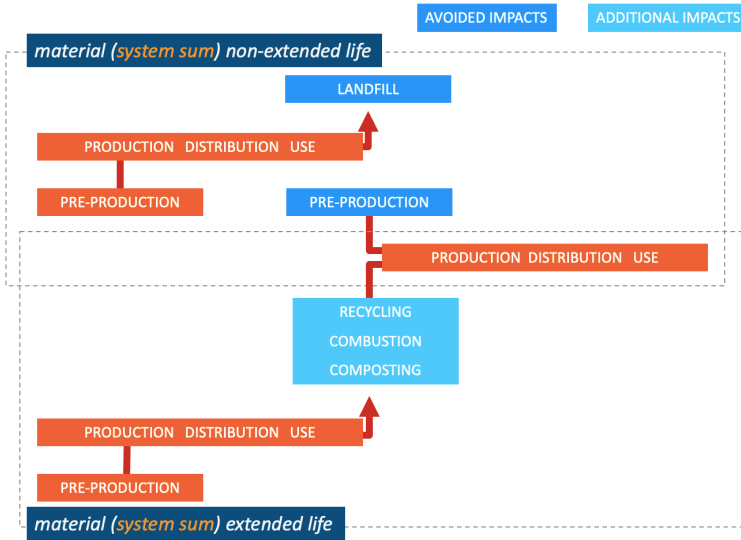


Fig. 3.31 Environmental advantages of extending the lifespan of materials of the whole of the products and support products of a certain system of satisfaction

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 characteristics, namely the performances recovery potential 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 minimisation/valorisation

- Complement products or infrastructures with take-back services aimed at recycling (facilitated by digital means where appropriate), included in the purchase price. **example 1**
- Complement products or infrastructures with take-back services aimed at (low-impact) energy recovery (facilitated by digital means where appropriate), included in the purchase price.
- Complement products with take-back services aimed at composting (facilitated by digital means, e.g., digital guide on correct streams, locations and timing, where appropriate), included in the purchase price.
- Create local partnerships aimed at symbiotic/cascade approach for recycling/composting of disposed products into others with lower requirements within other sectors. **example 2**

Examples

1.1 Modular photocopier remanufacturing - Xerox



Fig. 3.32 Top: Xerox employees during test and maintenance operations on different components; Bottom-left: printers in the warehouse waiting for disassembly and check-up operations; Bottom- right: tests on functional printer core⁵²

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.

⁵² Vezzoli, C. (2010) System Design for Sustainability: Theory, Methods and Tools for a Sustainable 'satisfaction-system' Design. Maggioli.

1.2 Recyclable shoe subscription - On 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 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 grow crops. The nature of this material makes the shoes bio-degradable and fully recyclable.

2.1 Open-source plastic recycling - 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



Fig. 3.33 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 process⁵³

plastic and manufacturing new products with it. There is also an online platform (dave-hakkens.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

⁵³ Precious plastic, (2022). Top figures Available at: <https://preciousplastic.com/>. Bottom figures Available at: <https://www.lens-international.org/>

resources and making their own DIY recycling and production machines. Precious Plastic also empowers/enhance local resources, since it helps enabling local distributed production using local waste.

2.2 Clothing take-back and renewal - Eileen Fisher

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 in-store 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 avoids pre-production of primary material and avoids 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 the system consuming high quantities of 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/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**
- Complement products or infrastructures with digital-enabled resource transparency, verification, and control services to address the use of biocompatible/renewable resources (e.g., selectable eco-materials / energy options, dashboard for impact / compliance information), included in the purchase price.

Examples

1. Decentralised renewable energy - 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. 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 Qcommunity website, the Qserver; together they constitute the Local Energy Network. Qbox is a Local Energy Network (LEN) In-

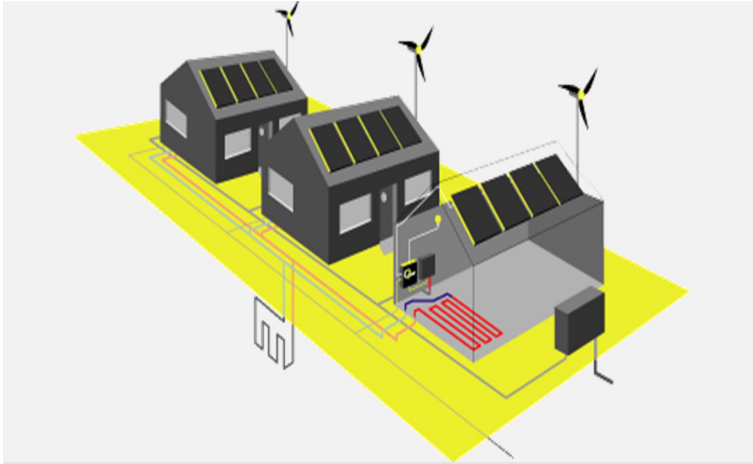


Fig. 3.34 Qurrent minigrid energy system layout⁵⁴

terface. 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 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.

⁵⁴ Vezzoli, C., Kohtala, C. and Srinivasan, A. (eds) (2014) Product-service system design for sustainability. Sheffield: Greenleaf Publishing.

2. Organic food distribution network - Visana



Fig. 3.35 From left to right: sample of Visana partner producer; Sample of producer shops; Visana brand and product⁵⁵

⁵⁵ Meroni, A., 2007. Creative communities. People inventing sustainable ways of living. Edizioni POLI.design, Milano. https://www.strategicdesign-scenarios.net/wp-content/uploads/2012/01/EMUDE_Creative-communities.pdf

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, 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. Regenerated textile production - Rifò Lab



Fig. 3.36 Retrieved textile materials organised by colour. Inset: sample product made from discarded textiles from other products.⁵⁶

Rifò Lab is an Italian company based in Tuscany that produces and sells clothes using fibres regenerated in the clothing manufacturing district of Prato. Its production is based on mechanical recycling methods that regenerate textile waste and used garments into new valuable fibres. Some products contain very high shares of regenerated fibres: for example, regenerated cashmere can contain 95% recycled cashmere, while regenerated denim products can contain high proportions of recycled denim or recycled cotton. In this way, Rifò's production relies only partly on virgin resources, since the company works with local suppliers and textile-recycling partners to use materials discarded by consumers or generated as waste in other sectors of the textile system.

56 RIFÒ LAB (2022).
Available at: [https://
rifo-lab.com/en](https://rifo-lab.com/en)

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

Guidelines for toxic reduction

- Create partnerships with recyclers or other producers to reuse or recycle toxic/harmful substances.
- Complement products or infrastructures or semi-finished products with services that minimise/treat toxic or harmful emissions they cause in pre-production, production and use stages, included in the purchase price. **example 1**
- Complement toxic or harmful substances or semi-finished products with end-of-life treatments, included in the purchase price. **example 2**
- Offer toxic management services to stakeholders of the product value chain, through payment based on the unit of satisfaction. **example 3**
- Complement toxic or harmful substances or semi-finished products with customer/technician training and guide services delivered via human or digital means (e.g., App or AR maintenance guides), included in the purchase price.

Examples

1.1 Lubricants-as-a-service - Klüber Lubrication



57 Klüber Lubrication
(2022)

Fig. 3.37 Klüber Lubrication monitoring consultancy⁵⁷

Klüber Lubrication moved beyond supplying lubricants to commercial customers by offering services that added value to product use. Through a service known as S.A.T.E., it analysed the effectiveness of aerosol treatment plants and wastewater treatment. For this purpose, Klüber Lubrication designed a mobile chemical laboratory in a van, which could monitor clients' industrial machines directly, assess the performance of the lubricants used and evaluate their environmental impact. The service also examined noise, vibration, smoke and other undesirable effects generated by industrial operations. This additional service helped clients improve plant efficiency, maintain functionality and durability, and strengthen environmental protection. The case therefore illustrates a shift from selling lubricants alone towards a product-service system based on technical monitoring, performance analysis and process improvement.

1.2 Smart recycling label - 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 Zyosh 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. Closed-loop solvent management - SAFECEM

SAFECEM Europe provides closed-loop solvent management solutions for industrial surface and metal cleaning. The SAFE-TAINER™ System combines the supply of fresh solvent with the collection of used solvent, reducing risks during solvent handling and supporting recovery after use. The system is based on two purpose-designed double-walled steel con-



Fig. 3.38 Double skin containers for the Safe-tainer system⁵⁸

⁵⁸ SafeChem Europe GmbH (2020). Available at: http://www.efkimya.com/pdf/katalog_16_serisi_1.pdf

tainers: one for fresh solvent and one for used solvent. The outer casing protects the inner drum during transport, handling, storage and use, while leak-tight couplings help prevent spills, leaks and vapour emissions during solvent transfer.

The container for fresh solvent is used to deliver virgin solvent while maintaining product quality. The container for used solvent is used to collect solvent removed from the customer's cleaning equipment, preventing accidental exchange with the fresh-solvent container. SAFECHEM supplies virgin bulk solvent to filling stations, normally located at the distributor's site, where it is stored and filled into the SAFE-TAINER™ System. The distributor then delivers both the fresh-solvent container and the used-solvent container to the customer.

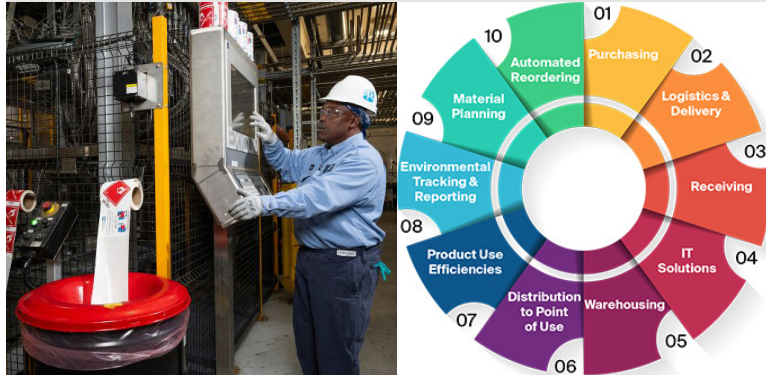
At the customer's site, the fresh-solvent container is connected to closed cleaning equipment through the accessories of the SAFE-TAINER™ System. During operation, used solvent is transferred into the designated used-solvent container, which is collected once full. The used solvent is then removed from the container and sent for professional management, including recycling where technically possible and proper

treatment or disposal of remaining residues such as distillation sludge. Recycled material can then be returned to the market, helping to close the resource loop.

By managing delivery, collection and recycling through the SAFE-TAINER™ System, SAFECHM supports safer and more resource-efficient solvent use. The company also complements the system with customer training and technical support, focusing on correct handling, safer transport and storage, and optimisation of the solvent cleaning process. This service component is central to the product-service system, because value is created not only through the solvent and container, but also through the management, knowledge and recovery processes that accompany them.

The SAFE-TAINER™ System is designed for companies using chlorinated solvents and modified alcohol solvents in closed surface-cleaning and metal-cleaning processes. In combination with modern closed cleaning machines, the system helps users handle solvents more safely, reduce emissions during transfer and improve waste management. The product-service system therefore enables SAFECHM to promote safer use, handling, transport and storage of solvents, while allowing end users to benefit from high-quality cleaning performance and improved environmental protection.

3. Chemical management services - PPG Industries



59 PPG (2020)

Fig. 3.39 Left: PPG employee operating on plant systems; Right: PPG chemical management service stage⁵⁹

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.

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

There are six principal areas of action/ strategies⁶⁰ 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;

- 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

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 studies⁵⁴ will also be provided for each criterion.

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 of forced or child labour?
- Are there any problems of health and safety risks?
- Are there any problems of exclusion (religious, cultural, gender, capacity, age, race) or insufficient support for people in the workplace?

- Are there any problems of workload and/or inadequate wages?
- Are there any problems of denial of association and rights to collective negotiation?
- Are there any problems of workers being dismissed without just cause (layoffs)?
- Are there any problems of technology applied, especially digital, to reduce employment?

Guidelines for improving employment and working conditions

- Offer access rather than mere product/equipment ownership to open new market opportunities for local entrepreneurs in low/middle-income contexts. **example 1**
- Improve and maintain good working conditions by **examples 2**:
 - Avoid/eliminate forced and underage work.
 - Avoid/eliminate forms of discrimination in the workplace.
 - Provide freedom of association and the right to collective negotiation.
 - Improve the health and safety of workers.
 - Define and adopt tools, standards and certification of social responsibility for the enterprises/organizations.
 - Employ technology, especially digital, where it is physically or psychologically dangerous and unhealthy.
 - Employ technology, especially digital, to amplify capabilities.
- Promote adequate working hours and fair wages by:
 - Guarantee that wages are fair and adequate to the number of working hours.
 - Guarantee an adequate number of working hours.
 - Verify/request from suppliers of semi-fin-

- ished products and/or services for the company guarantees regarding the quality and fair remuneration of their workers.
- Promote satisfaction, motivation and participation of the employees by **example 3**:
 - 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.
 - Make employees shareholders of the company/organization while enhancing their influence in its strategic decision-making.
 - Create a working climate that takes into consideration innovations suggested by workers.
 - Collaborate with colleagues to offer good working conditions in the whole value chain.

Examples

1. Secure 3D printing service - Lowe's Innovation Labs

Lowe's Innovation Labs developed a project in partnership with Authentise to provide secure distribution tools and services for in-store and online 3D printing and scanning. The software allowed 3D files to be streamed directly to 3D printers without being downloaded, helping protect designers' files from unauthorised use or distribution while simplifying the process for users. Secure file distribution also encouraged designers to distribute and sell their designs online. The service made 3D printing more accessible to users with limited knowledge of the technology.

Customers could purchase a 3D file, customise the design using software provided through Lowe's service, and have

it printed in a selected material, such as plastic, steel or gold. In this case, they paid for the final product according to the chosen customisation, material and production requirements. Customers could also use in-store printers and scanners to scan objects or print their own files, paying for the service and materials used.

This initiative helped bridge the gap between consumers and 3D printing by giving them access to tools, assisted services and secure digital distribution. It also suggested a model through which retailers and other businesses could provide 3D printing and scanning services to customers.

2.1 Sustainability reporting standards - GRI



Fig. 3.40 GRI sets a new global benchmark for sustainability reporting⁶¹

The Global Reporting Initiative (GRI) is an independent international organisation, headquartered in Amsterdam and supported by regional networks around the world, that helps businesses, governments and other organisations understand and communicate their impacts on the economy, the environment and people. GRI acts as a global platform for transparency, accountability, reporting and sustainable development. Its vision is a world in which organisations are accountable for their impacts on the economy, people and planet, and its mission is to provide global leadership in sustainability reporting.

GRI develops and regularly updates the GRI Stand-

⁶¹ Global Reporting Initiative (2022). Available at: <https://www.globalreporting.org/standards/standards-development/universal-standards/>

ards, which have replaced the earlier Sustainability Reporting Framework and Sustainability Reporting Guidelines. The Standards support comparable, credible and consistent reporting by organisations of different sizes, sectors and legal forms. They are developed through a global multi-stakeholder process involving businesses, investors, policymakers, civil society, labour organisations and experts. By adopting the GRI Standards, organisations can improve transparency towards stakeholders, strengthen accountability and communicate how they manage issues affecting workers, communities, consumers and the environment.

2.2 Social accountability certification - SA8000



Fig. 3.41 Anker Research Institute's Living Wage and Income Corporate Sponsors program⁶²

SA8000 is an international standard for improving working conditions and social accountability in workplaces. Based on internationally recognised human-rights and labour standards, including the Uni-

⁶² Marcel Crozet/ ILO (2022). Available at: <https://www.flickr.com/photos/ilopic-tures/49846155588/in/album-72157714133161636/album-72157714133161636/>

versal Declaration of Human Rights, ILO conventions and national laws, it is a tool that helps organisations apply these principles to practical working situations. Specific enough to be used by audit bodies and contractors in different industries and countries, SA8000 was one of the first credible auditable social standards and is independent of governments and single interest groups.

To certify conformity with SA8000, each organisation seeking certification must be audited by an accredited certification body. Auditors visit facilities, assess company practices across a wide range of labour-rights issues and evaluate the management systems needed to ensure continual improvement and ongoing acceptable practices. Once an organisation has implemented the necessary improvements, it can obtain a certificate attesting to its compliance with SA8000. This certification provides external assurance to consumers, buyers and other companies, and is intended to support the improvement of workplace conditions.

Benefits for workers, trade unions and NGOs are:

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

Benefits for businesses are:

- Enhanced company and brand reputation.
- Improved employee recruitment, retention and productivity.
- Support for better supply-chain management and performance.

Benefits for consumers and investors are:

- Clearer and more credible assurance for ethical purchasing decisions.

- Identification of companies committed to ethical sourcing and decent working conditions.
- Broad coverage of product categories and production geographies.

3. Employee-owned browser company - Vivaldi



Fig. 3.42 Vivaldi team and logo⁶³

⁶³ Vivaldi Technologies (2026). Available at: <https://vivaldi.com/press/>. Licensed under CC-BY-4.0.

Vivaldi is a freeware, cross-platform web browser developed by Vivaldi Technologies, founded by former Opera CEO Jon Stephenson von Tetzchner. The company is headquartered in Norway, is employee-owned and has no external investors, giving employees greater influence over its direction. Built on Chromium, the browser combines advanced functionality with extensive customisation and privacy. Users can personalise UI elements, manage complex workflows with tab stacking and tiling, and use built-in tools such as mail, calendar and feed reader. It also includes native ad and tracker blocking, private browsing, Web Panels and Quick Commands, serving as a flexible, privacy-conscious alternative for power users.

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 there any problems affecting external organisational stakeholders?
- Are the clients or final users expressing concerns or criticism about the supply system?
- Are there any unfair relationships in the partnerships with stakeholders?
- Are there any unfair relationships with suppliers, sub-contractors and / or sub-suppliers?
- Does the solution employ automated channels, such as bots or artificial intelligence, to handle user / client complaints, to discourage or replace potentially more effective human interaction channels?
- Does the solution exploit users or other stakeholders to generate data by surveilling, nudging or using other dark patterns, increasing users' / other stakeholders' exposure to profiling and behaviour manipulation for commercial or political interests (instrumentalisation)?
- Does the solution diminish, ignore, or oppress users or other stakeholders, reinforcing injustice or inequalities through algorithm activity raising concerns regarding bias and accountability?
- Does the solution contribute to, or concerns, psychological or societal harm, such as addiction, depression, isolation, polarization, or any reduced wellbeing for users or other stakeholders?

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 organizations engaged in the diffusion of social equity standards.
 - Promote and facilitate knowledge exchange between partners and stakeholders.
 - Offer stakeholders' adequate information flow.
 - Increase stakeholders' productive capacity.
- Promote and enhance fair 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 supplier, 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 fair 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.
- Employ a Digital Passport System to enable users and other stakeholders to verify identity, rights, and entitlements transparently across services and products, ensuring equity, accountability, and data sharing of sustainability enhancing essential information.
- Promote and enhance fair and just relations with the community where the product-service system operates/is deployed. **example 2**
 - Verify that the offer doesn't 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.
- Promote and enhance informational relations with clients and/or end-users, protecting them from data extraction and organizational centralization (data silos). **example 3**
 - Offer services that alter personal data to make it unidentifiable to outsiders.
 - Use decentralized systems in the solution where users do not rely on a single company to store/process data, to confirm their identity, or to communicate.
 - Limit or eliminate the use of personal data (users), unsmarting devices through not collecting data (privacy by default policies), offline connections (cable, Bluetooth), and/or blocking the collection of data.

Examples

1.1 Fair trade certification system - Fairtrade International



Fig. 3.43 Fairtrade mark and product bearing the mark⁶⁴

⁶⁴ Fairtrade (2022). Available at: <https://www.fairtrade.net/about/fair-trade-marks>

Fairtrade International, established in 1997, is a non-profit umbrella organisation that unites 22 member organisations, including three producer networks in Africa and the Middle East, Asia-Pacific, and Latin America and the Caribbean, as well as 19 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 Fairtrade Minimum Price and provide an extra Fairtrade Premium. Fairtrade Standards go further than simple codes of conduct and many social labels: besides minimum requirements that producers and traders must meet, they include development requirements intended to improve working conditions, increase the environmental sustainability of activities and support organisational development for workers and small farmers.
2. Producer business support, which facilitates producers' compliance with the Fairtrade Standards and provides them with information to strengthen

their businesses and access new market opportunities.

3. The FAIRTRADE Mark is an independent consumer label that appears on products as a guarantee that producers and traders have met Fairtrade Standards. Fairtrade certification supports farmers and workers by enabling investment in farms, communities, environmental protection and business skills. In order to display the FAIRTRADE Mark, a product must meet international Fairtrade Standards. Independent certifiers, mainly FLOCERT, audit producers, traders and companies and check compliance with economic, social and environmental standards. These include, for example, payment of the Fairtrade Minimum Price, which acts as a safety net for producers, and the Fairtrade Premium, extra money that can be invested in social, economic and environmental development projects.

The Fairtrade principles include:

01. Fair price: democratically organised farmer groups receive at least the Fairtrade Minimum Price and an additional Fairtrade Premium. Farmer organisations may also be eligible for pre-financing.
02. Fair labour conditions: workers on Fairtrade farms have freedom of association, safe working conditions and protection from forced labour and the worst forms of child labour.
03. Direct trade: Fairtrade aims to support more stable trading relationships between buyers and Fairtrade producer groups, reducing unnecessary intermediaries where possible and strengthening producers' business capacity.
04. Democratic and transparent organisations: Fairtrade farmers and workers decide democratically how to invest Fairtrade Premium revenues.
05. Community development: Fairtrade farmers

and workers invest Fairtrade Premiums in social, environmental and business-development projects, such as scholarship programmes, quality-improvement training and organic certification.

06. Environmental sustainability: Fairtrade Standards restrict hazardous agrochemicals and prohibit GMOs in favour of more environmentally sustainable farming methods that protect farmers' health and preserve ecosystems for future generations.

1.2 Fair trade enterprise verification - WFTO

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 that producers' voices are heard. More than 400 Fair Trade enterprises and support organisations in over 70 countries form the basis of the network, with a large share of members based in producer regions across Asia, Africa, Latin America and the Middle East. WFTO's primary role is to verify Fair Trade Enterprises against the 10 Principles of Fair Trade. It assesses the whole business, from the enterprise's structure and business model to its operations and supply chains, and not only a specific product, ingredient or supply chain, as in the case of the FAIRTRADE Mark or other commodity certifiers.

WFTO's work is centred around three areas:

- Market development: WFTO encourages the development of the Fair Trade market to increase opportunities for marginalised, small-scale producers.
- Fair Trade monitoring: to help increase public trust in Fair Trade organisations, WFTO uses a struc-

tured monitoring and verification scheme called the WFTO Guarantee System. This scheme verifies whether members practise Fair Trade across their business and supply chains. It includes a membership admission procedure, Self-Assessment Report, Monitoring Audit, Peer Visit and Fair Trade Accountability Watch. WFTO members, once fully verified, are entitled to use the WFTO Guaranteed Fair Trade label on their products.

- Advocacy: WFTO speaks out for Fair Trade and for related issues, including the overuse of natural resources, women's empowerment, refugee livelihoods, human rights, inequality and sustainable farming.

1.3 Fair trade network - Altromercato



Fig. 3.44 Altromercato's producers⁶⁵

Altromercato is the main fair trade organisation in Italy. It is a social enterprise made up of more than 80 members and around 200 shops in Italy, where fair trade products are offered and information and education are provided on global trade inequalities. Altromercato products can also be found in supermarkets, local shops, online channels and public food services. Altromercato was created in Bolzano in 1988 by different groups of people and associations in response to unequal commercial relations between North and South. Fair trade is based on a fair price paid to producers and on equitable relations between

⁶⁵ Altromercato (2022). Available at: <https://www.altromercato.it/el-ceibo/>

small groups of democratically organised producers and Altromercato's purchasing network. The project contributes to respecting producers' rights and facilitating trade with economically disadvantaged communities and countries. Altromercato also promotes information, education and cooperation activities. Its supply chains include fair trade, organic and sustainable products, but not all suppliers are exclusively organic. Altromercato is a guaranteed member of the World Fair Trade Organization (WFTO).

2. Bicycle reuse and repair - Uusi Tuuli



Fig. 3.45 The Bicycle Flea Market project⁶⁶

The Bicycle Flea Market repaired and resold donated bicycles in Turku, Finland. Run by Uusi Tuuli, it was operated by volunteers, many of whom were unemployed people willing to work for the common good and maintain their repair skills. The flea market initially sold

⁶⁶ Meroni A., (edit by), Creative communities. People Inventing sustainable ways of living, Edizioni Polidesign, Milano, 2007. https://www.strategicdesign-scenarios.net/wp-content/uploads/2012/01/EMUDE_Creative-communities.pdf

a range of goods, but later focused on bicycles. Volunteers worked for two to four hours every weekday. They were sometimes joined by people sent by the Unemployment Office, who learned how to use tools and repair bicycles and usually left after three months with new skills. Repaired bicycles were displayed next to the entrance, and new owners received a warranty of one month or more. The activity helped develop or maintain manual skills and enabled workers to feel that they were a valuable part of society. Those who chose to work there were willing to learn and teach others. The project promoted employment, ecological transport, waste reduction and the transformation of abandoned bicycles into valuable products, benefiting the community of Turku. Customers benefited from cheap bicycles with a warranty, while students in Turku could save money on public transport and commute in a more environmentally friendly way.

3. Privacy-focused web browser - Brave

Brave is a free, privacy-focused web browser built on Chromium that automatically blocks most advertisements, third-party cookies and website trackers in its default settings. By reducing tracking and profiling, it helps protect users from data extraction and the concentration of browsing data in advertising platforms and organisational data silos. Users can also turn on privacy-preserving ads, which are matched on the user's own device, and receive rewards for their attention in the form of Basic Attention Tokens (BAT). Brave is open source, with publicly available repositories on GitHub. The browser also offers educational materials on digital literacy, including guides on privacy, Web3 and AI.

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 social (un)sustainable behaviour promoted by the supply system?
- Is the client / final user able to clearly and easily recognize and understand the socio-ethical (ir)responsibility / (un)sustainability throughout the entire data chain - including usage, processing, applications, regulation, impact, and physical infrastructures, etc?
- Is the client / final user able to reduce their vulnerability caused by weak privacy protections and limit their exposure to profiling, and behaviour manipulation?
- Is the client / final user able to engage in discussions, contribute ideas about how their data are used, and participate in the development and governance of the data system (rather than passively exploited)?

Guidelines for enabling and promoting responsible and sustainable consumption

- Enhance the social sustainability of all users by:
 - Adopt standards to increase the transparency of supply chains, underlining their social sustainability;
 - Implement achievements and challenges for users in digital platforms to gamify sustainable usage.
 - Design default choices on digital platforms towards sustainability.
- Complement the S.PSS offer with the information and/or learning experiences to educate the client/end-user. **example 1**
 - Embed sustainability education and actionable tips in the user experience throughout the system's use.
 - Provide visualisation of the environmental impact for the user.
 - Embed user training on proper use to avoid damage and inefficiency.
- Offer S.PSS that enable clients/end-users to participate responsibly/sustainably. **examples 2**
- Involve the client/end-user in the production/implementation/ customisation of their S.PSS. **examples 3**
- Involve the client/end-user in the design/decision-making process of their own S.PSS. **example 4**
- Adopt standards to increase the transparency of supply chains, underlining its social sustainability.
- Enhance the privacy of all customers/users and enhance the transparency of the system.
 - Do not collect unnecessary personal (customer/user) data by default (privacy-by-design).
 - Offer offline connections, such as cable, Bluetooth, or downloadable software.

- Ensure that any personal data not essential to system operation remain accessible only to the user/customer. Ensure that personal data access permissions are designed to be clear and easy for users/customers to manage themselves.
- Complement the S.PSS offer with services to users/clients learn and be aware of the provider's commercial trading of personal data.
- Engage the user/customer in designing the system to ensure transparency, accessibility, and user control over personal data management.

Examples

1. Stockfree organic learning farm - Tolhurst Organic

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. It also provides a model for stockfree, or animal-free, organic farming and was the first farm 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 stockfree organic farming. Stockfree organic systems can use less land than livestock-dependent systems, have a lower carbon footprint and require less energy. Growing food without animal inputs can also reduce some risks linked to pathogens, antibiotics and chemical residues from manure.

Tolhurst Organic aims to promote sustainable production and consumption by showing how to produce high-quality, locally available and organically grown food without slaughterhouse by-products or animal manures. Besides providing vegetable boxes to customers and selling produce through local channels, the farm offers on-farm opportunities ranging from school visits and farm walks to volunteer opportunities and placements. Activities include nature walks, beetle watching, bird watching, berry collection, weeding, harvesting, compost mixing and sketching.

The farm also offers three-month traineeships to local and international students and future growers, from April to July and from August to October. In addition, specialist organic advice for farmers, growers and students is available and delivered in different forms, including at Tolhurst Organic, on other farms or remotely.

2.1 Community bicycle services - +BC



Fig. 3.46 Street bike workshops⁶⁷

+BC, standing for the vernacular Italian for “more bicycles”, is an Italian association supported by the Municipality of San Donato Milanese. It brings together bicycle experts, inventors and enthusiasts who encourage the culture of cycling in the city by supplying services such as second-hand bicycle hire, technical

⁶⁷ +BC (2022). Available at: <https://www.piubici.org/attivita/ciclofficine-di-strada/>

assistance, maintenance and creativity workshops, parking facilities and bicycle security. It also organises cultural activities and provides consultancy services on sustainable transport. +BC's services are open to everyone, with no membership system. The +BC workshops are managed by users under the supervision of an expert mechanic. The solution empowers people by helping them to use bicycles instead of cars and by teaching them how to repair their own bikes. The service enables users to maintain their bicycles at a low price. Cycling contributes to a better environment and a healthier lifestyle. Finally, +BC fosters the integration of bicycle and metro transport, helping to address traffic and pollution problems in large cities.

2.2 Shared community garden - Jardin Nomade

Jardin Nomade, supported by the Association du Quartier Saint-Bernard (QSB11), a district association in Paris, is a shared community garden. Local inhabitants take care of this collective space, while an environmental education programme for children, promoted with local schools, also takes place there. Various events are organised, from community celebrations to workshops and activities open to everyone: gardeners, association members, neighbourhood residents, passers-by and other visitors. Access is free when the garden is open and a gardener is present. Jardin Nomade is part of the Main Verte network created and run by the City of Paris, a programme designed to respect the environment and biodiversity while encouraging local participation and civic responsibility, especially among young people. Jardin Nomade promotes interaction between generations and environmental awareness; it involves schools and associations and helps create a healthier neighbourhood environment.

3.1 Resident-led neighbourhood maintenance - The Hague



Fig. 3.47 Neighbourhood shares instruments and tools⁶⁸

Residents took over responsibility from the local authority for certain maintenance tasks in their neighbourhood, such as tending gardens and tidying streets. The residents' association decided, together with the local authority, what work needed doing, then organised it among local residents. Although the local authority paid for the work, responsibility was devolved to the residents' association. The local authority and environmental organisations provided practical advice and environmental-awareness support. Residents learned how to take care of their own environment and became motivated to carry out maintenance tasks. By showing residents how to value, maintain and care for their own environment, this area of The Hague became a useful example for other cities. By tending gardens and tidying streets, the project made this part of The Hague a healthier and more pleasant place to live.

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

⁶⁸ Meroni, A., 2007. Creative communities. People inventing sustainable ways of living. Edizioni POLI.design, Milano. <https://www.strategicdesignscenarios.net/downloads/Publications/Creative%20Communities.pdf>

3.2 User files Independence - Obsidian

Obsidian is a personal note-taking software application that works with local Markdown files, allowing users to create internal links between notes and visualise the connections as a graph. The software is free to use, with optional paid services such as Sync and Publish. It focuses on ownership and portability of users' files, since notes are stored locally rather than locked into a proprietary cloud format. Obsidian also enables extensive customisation through themes and community plugins, allowing users to adapt the software to their own workflows and needs.

4. Self-build eco-housing - Earthship

Earthship houses offer people in the 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 courses, giving people the opportunity to understand how to build or adapt their own homes. People can decide to start building or restoring their houses according to environmental sustainability principles, although professional advice and planning approval may still be needed. Each Earthship is a passive solar building



Fig. 3.48 'Building their own home' course⁶⁹

⁶⁹ Brighton Permaculture Trust (2022). Available at: <https://brightonpermaculture.org.uk/self-building-an-earthship/>

made from natural and recycled materials, powered by renewable energy such as wind, water and solar power, harvesting its own water from rainwater and treating its own wastewater in planter beds. It is a concept rather than a fixed design, and can be adapted to different climates worldwide. The purpose of Earthship is to inform people of simple ways in which they can reduce their impact on the environment.

The construction of Earthship houses, using reclaimed tyres filled with compacted earth and a glazed south-facing wall, provides thermal mass, heat retention and insulation. This approach was tested in Scotland through Earthship Fife, built between 2002 and 2004, and in England through Earthship Brighton, which continues to offer tours and training courses on Earthship construction.

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 create obstacles or limit access to people with weaker social status (e.g. children, elderly, disabled)?
- Is the offering accessible to people with low income?
- Does the offering system contribute or reinforce the marginalisation (immigrants, ethnic minorities, etc) of certain people?
- Are people being excluded due to digital structures

- and systems - lack of access to affordable Wi-Fi and devices (digital divide)?
- Are people being excluded due insufficient knowledge on the use of digital technology (digital illiterate), or algorithmic injustice (reinforcing oppression, prejudice, persecution, censure, biases and existing inequalities?

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

- Offer the access rather than mere product ownership to extend it even to low-income final users. **example 1**
- Complement the product offer with the all-inclusive running costs (e.g. maintenance, repairs, upgrade, etc.) to avoid their 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. **example 4**
- Develop systems which allow easier access to credit (for companies). **example 5**

- Involve weaker people and improve their quality-of-life conditions. **example 6**
- Involve and improve the conditions of marginalised persons offering them qualifying jobs which enhance their competences.
- Involve and facilitate introducing foreigners into the social context/space.
- Introduce digital technologies into the product-service system when they can support low-income, weaker, and marginalized individuals/communities in meaningful ways. **example 7**

Examples

1. Toy lending service - Toy libraries



Fig. 3.49 TLASA provides toy library information and recognised training to toy librarians⁷⁰

⁷⁰ TLASA (2022). Available at: <https://tlasa.org/>

In a toy library, a variety of toys, games, puzzles and educational aids can be borrowed in a way that is similar to a public library. Toy libraries may organise play sessions for families and offer a wide range of toys appropriate for children at different stages of de-

velopment. They provide children with new toys every week or two, saving parents money and preventing toys from being quickly discarded or under-used. Members usually have access to a stock list, organised by age or area of development. Advice may also be supplied by toy-library personnel during item selection and on other child-related issues.

Families who want to borrow toys from a toy library usually become members. In some cases, items may also be purchased after a “test drive”, helping ensure that the child finds the item useful. After choosing items, families can normally keep them for around two weeks, then return and exchange them for other toys. When an item is returned, it is checked to see whether everything is in order. Members are asked to clean items before returning them, while the toy library also carries out cleaning and hygiene checks. Toys are selected to be durable, interesting, low-maintenance and unlikely to have many lost or broken parts. Toys without batteries and without too many small parts are often preferred. Websites commonly explain how items are organised according to skills and ages, with photos of toys in different categories. If a toy breaks, the action taken by the toy library depends on the extent of the damage. If a toy is completely broken or lost, the member may have to pay the replacement cost. If it can be repaired and made fully functional again, the toy library repairs it and may charge the member a penalty to cover costs.

Items are used to their maximum potential, rather than being bought by one family, used briefly and then discarded when no longer needed. In this way, they are used many times. In other words, the use of toys and educational items is maximised to meet a given demand: fewer products are needed, because the same product is made available to a higher num-

ber of people. From the consumer point of view, the economic benefit is evident, since families do not need to spend large amounts of money buying toys that will be replaced within a short period. Across the world, including 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 1960s and 1970s, supported by programmes such as Head Start and other legislation. For example, the Toy Library Association South Africa is a registered non-profit organisation that promotes best practice in the field of toy libraries, play and toys in South Africa.

2.1 Open solar cooking network - Solar Cookers International

Open solar cookers are clean, safe and low-cost cooking systems that are easy to build and use. Simple panel cookers, such as the CookIt, are made with reflective panels and a heat-resistant bag, and can be used to cook food or pasteurise drinking water. Larger and different types of solar cookers are also used in health centres, schools and small enterprises, for example to heat water, cook food, bake, process honey or support textile activities. Solar Cookers International supports the diffusion of solar cooking by providing information, training and technical guidance, and by helping adapt cookers to different climates and food practices. In Kenya, solar cooking projects have been implemented in refugee camps, including Kakuma, where women and local trainers have helped spread the use of solar cookers within the community. Solar cookers use solar energy instead of wood or charcoal. In sunny areas, they can reduce the use of traditional fuels, contributing to lower deforestation pres-

sure and fewer emissions. They can also pasteurise drinking water, helping reduce diseases caused by unsafe water. Solar cookers can be made from a range of recyclable or recycled materials. By reducing smoke, soot and burning, they can also improve indoor air quality, reduce respiratory problems, keep pots cleaner and reduce the need for detergents.

2.2 Self-powered radio - BayGen Freeplay



Fig. 3.50 BayGen Freeplay⁷¹

⁷¹ Science Museum Group (2022). Available at: <https://collection.sciencemuseumgroup.org.uk/objects/co432265/baygen-free-play-wind-up-radio-a-portable-receiv-windup-radio>

BayGen Freeplay is a hand-powered radio covering FM, MW and SW frequencies. It does not need disposable batteries or grid electricity, as it is powered by a hand-cranked generator that charges an internal energy-storage system. The inventor, Trevor Baylis, was inspired by a television documentary on communication difficulties in Africa, where radio access was limited by the cost of electricity and the unreliable supply of batteries. Baylis' idea was to use human power instead of conventional energy sources. After the crank is turned for a short time, the radio can be used for a longer listening period, depending on the model and conditions of use. If switched off before the stored energy is exhausted, some models retain the remaining charge for later use. BayGen Freeplay re-

duces the consumption of energy resources because it is not powered by grid electricity or disposable cells during use. It also reduces the need to produce, distribute and discard batteries, which can create waste and toxic pollution when not properly managed. Free-play Energy, founded after Baylis' invention, continues to produce wind-up and solar-powered radios and lighting products for aid, development, emergency-preparedness and outdoor uses.

3. Time-based service exchange - Time banking



Fig. 3.51 An image representing the Time Bank concept⁷²

Time banking is a system of service exchange that uses units of time as currency, with one hour of any person's labour valued equally. It gives people the possibility to meet others and exchange labour, services and assistance with everyday problems on an equal basis, without differences between types of work. The exchange is based on hours, not on market value or performance. Each person's hour has the same value. No money is used; instead, time credits are recorded to show the amount of services exchanged. Essentially, the time one spends providing community services earns the time that one can spend receiving services. Different types of services can be exchanged, depend-

⁷² Pixabay (2022). Available at: <https://pixabay.com/illustrations/save-time-save-time-time-is-money-1667023/>

ing on what people can offer. Examples include repairing electrical faults, cooking, language conversation, animal care and plant care. The aim is to satisfy the material and social needs of everyone in a cooperative and friendly context. Communities use time banking as a tool to build stronger intra-community connections and social capital. Modern time banking was developed in the United States in the early 1980s by Edgar Cahn, with the principle that one hour of service equals one hour. In 2013, TimeRepublik launched a global timebanking platform, aiming to reduce the geographical limits of local time banks.

4. Long-distance ride sharing - BlaBlaCar



Fig. 3.52 App of the Carpooling service by BlaBlaCar⁷³

⁷³ Blablacar (2022). Available at: <https://newsroom.blablacar.com/ressources>). Used for educational, non-commercial purposes.

BlaBlaCar is a platform for long-distance ride sharing that connects drivers and passengers who want to travel together between cities and share the cost of the journey. Drivers can publish information about their route, departure time, available seats and price per seat on the platform, and passengers travelling on the same route can request or book a place in the car. The platform therefore lets users connect through

shared information and services, supporting Distributed Information and Distributed Services. The hardware used to access this information is mainly mobile devices, but also computers. However, this service does not apply a PSS model to the access devices themselves.

5. Ethical credit for social enterprises - Banca Etica

Banca Popolare Etica is an Italian cooperative bank that supports access to credit for organisations and enterprises working in social and environmental sustainability. It collects savings from people and organisations that want their money to be managed responsibly and transparently, and uses these resources to finance projects that generate social and environmental value. For companies, social cooperatives and other organisations, Banca Etica offers credit not only on the basis of economic assessment, but also through evaluation of the applicant's social and environmental profile. This facilitates access to finance for enterprises that may be poorly served by conventional banking but are able to produce positive impacts for communities and the environment.

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



Fig. 3.53 The Coach House Trust provides structured workshops in Art, Gardening, Woodwork, Computing, Music and Healthy Eating⁷⁴

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

⁷⁴ The Coach House Trust (2022). Available at: <http://www.thecht.co.uk/index.html>

health problems, recovering from addiction or with learning difficulties, who find it difficult to find and keep a job. The Coach House gives them focus and 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 participants into the mainstream community. It achieves this through 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 such as fruit and vegetables, woodwork and metalwork sculptures, paintings and silk paintings were sold through the shop. People who have experienced addiction or mental illness are often ignored in everyday society but are welcomed at the Coach House. It gives them opportunities to learn new skills, meet people with similar experiences and take part in sustainable practices, such as woodwork, mosaics, metalwork, slab-making, furniture-making, gardening and recycling.

Much of this work benefits local society. The team has renovated public spaces and landscaped local private gardens. The non-profit organisation is funded by various bodies, including health authorities and charities. Regular attendees require funding, which goes towards training, materials, equipment and staff. It would be difficult for the trust to find enough funding to expand, even if it wanted to, meaning that new clients may be unable to join or participate. Any work sold through the shop, restaurants or markets contributes to materials, tools and related costs.

6.2 Senior cohousing community - Aquarius



Fig. 3.54 The Coach House Trust provides structured workshops in Art, Gardening, Woodwork, Computing, Music and Healthy Eating⁷⁵

Aquarius is a senior cohousing community in which about 45 older people live in separate but nearby homes, helping one another according to their different abilities and needs. The community consists of 30 private two-storey houses with gardens, together with a large common room, a shared kitchen and a large park. The Aquarius association is responsible for meeting potential new residents and carrying out an initial selection. Preference is given to active people aged between 55 and 65 who are willing to participate in mutual help. Living in the community encourages social relations and active ageing, gives residents and their families a greater sense of safety, and can reduce avoidable demand for public care services.

⁷⁵ Meroni, A., (2007). Creative communities. People inventing sustainable ways of living. Edizioni POLI.design, Milano. <https://www.strategicdesignscenarios.net/downloads/Publications/Creative%20Communities.pdf>

7. Anonymous operating system - Whonix

Whonix is an open-source operating system developed by independent contributors. It runs like an application in a virtual machine and routes internet traffic through the Tor anonymity network. It offers privacy protection and online anonymity by separating the user's working environment from the network gateway. Users may include investigators and whistle-blowers, researchers, government officials or business people who may be targets of espionage, journalists, activists, computer users in repressive or censored environments, and users who do not want aspects of their private lives to be collected, stored and analysed online.

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, promoting, or reinforcing any form of intra-gender, intra-cultural, intra-generational, intra-capabilities marginalisation?
- Is the offering system creating, promoting, or reinforcing any forms of discrimination (sexual, religious, cultural, gender, capabilities, age)?
- Is the offering system creating, promoting, or reinforcing mistrust, exclusion, unhealthy competition, or communication breakdowns within groups or among individuals?
- Is the offering system creating, promoting, or reinforcing any form of digital marginalisation (of knowledge, algorithmic, or equipment)?
- Is the offering system creating, promoting, or reinforcing any form of division, disarranging or disorganizing social movements (towards better rights, to develop small business, etc.), especially using psychological operations on digital media?

Guidelines for improving social cohesion

- Promote products, spaces, infrastructures, knowledge, services sharing system, enabling neighbourhood social integration. **example 1**
- Promote products, spaces, infrastructures, knowledge, services sharing system, enabling common goods and their maintenance within neighbourhoods.
- Promote products, spaces, infrastructures, knowledge, services sharing system, enabling co-housing.

- Promote products, spaces, infrastructures, knowledge, services sharing system, enabling inhabitants in common goods co-design.
- Promote products, spaces, infrastructures, knowledge, services sharing system, enabling social integration between generations. **example 2**
- Promote products, spaces, infrastructures, knowledge, services sharing system, enabling gender integration. **example 3**
- Promote products, spaces, infrastructures, knowledge, services sharing system, enabling social integration between different cultures.
- Integrate online communication & user engagement channels for users/clients and stakeholders to help communities come together. **example 4**
 - Incorporate in-app direct communication channels for users/clients and stakeholders.
 - Send users/clients and stakeholders notifications and alerts for key events.
 - Actively enable social sharing and community features to foster stronger connections between users/clients and stakeholders.
 - Actively solicit digital feedback and user contributions aiming at empowering users and foster a sense of inclusion within the community.
 - Broadly communicate sustainability updates and achievements to users and stakeholders to build shared purpose, reinforce positive impact, and foster a sense of collective responsibility.
 - Implement features that facilitate peer-to-peer interaction and support, especially between more experienced and less experienced users.

Examples

1. Participatory eco-district - Vauban



Fig. 3.55 Sustainable Urban District Vauban⁷⁶

76 Left figure: © Sromuald; Right figure: © Arnold Plesse. Available at: Urban Sustainability Exchange (USE) case study section (2022). <https://use.metropolis.org/case-studies/sustainable-urban-district-vauban>

Vauban is a neighbourhood of Freiburg, in south-west Germany, specifically planned and built as a sustainable urban district. The area, formerly used as a military base, was redeveloped according to ecological and social-cohesion criteria. The goal was to build housing for people with different lifestyles and social backgrounds, combining living and working functions close to the city centre. It includes co-housing connected with social and environmental projects.

Vauban's sustainable district development was promoted by Forum Vauban, which organised working groups, information campaigns and other activities related to district development. Citizens took part in management by working in groups to discuss transport, energy and communal-living issues. Vauban implemented a successful model for alternative mobility: it is a largely car-reduced neighbourhood, with traffic prohibited in many streets and parking concentrated near the district entrance. Green areas and public spaces are prioritised and play an important role in social cohesion.

Many houses were built in an environmentally oriented way, based on renewable energy, energy efficiency and bioclimatic architecture principles. The

SUSI cooperative also converted former barracks into self-managed housing. The neighbourhood acts as a place of aggregation and co-planning. Citizens' cooperation helped create a district that responds to the needs of its inhabitants. Sustainable urban districts like this help develop people's autonomy while diffusing environmental awareness and promoting sustainable living.

Examples of high levels of environmental sustainability within the district include:

- Energy: low-energy, passive-house and plus-energy buildings; active use of solar energy; some houses produce more energy than they need.
- Transport: reduced car use; priority given to pedestrian, bicycle and public transport; cars parked mainly near the district entrance.
- Homes: co-building groups and cooperative housing; technical learning on ecological building; bio-architecture principles applied in construction and maintenance.
- Water: rainwater management, natural infiltration and pilot sanitary systems, including biogas generation in some buildings.

2. Crowdsourced invention platform - Quirky

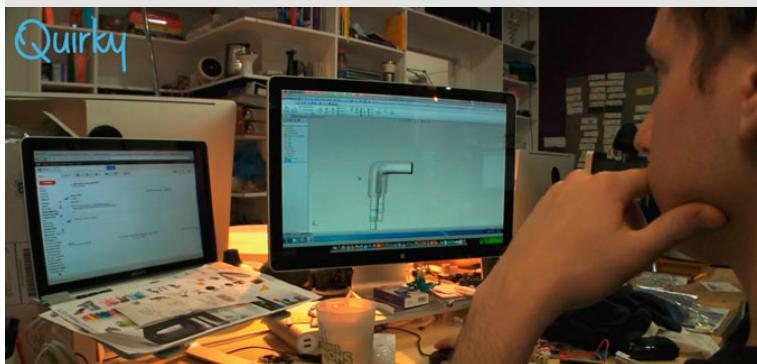


Fig. 3.56 Quirky invention platform⁷⁷

⁷⁷ 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.

78 The Economist (2012). Available at: <https://www.economist.com/special-report/2012/04/21/all-together-now>

Quirky was an invention platform that connected inventors with users who had complementary skills for developing ideas, and with companies specialised in specific product categories for manufacturing and commercialisation. The platform gave users access to a complete product-development process and incorporated originating designers and other contributors into a revenue-sharing model⁷⁸.

Users could submit ideas and collaborate with others to develop them through the platform. Once a developed idea was selected through community evaluation and Quirky's product-review process, it could be pitched to manufacturing or commercial partners. If the product was manufactured and sold, Quirky shared royalties with the inventor and other contributors according to their level of influence, evaluated through the platform's point system. In socio-ethical terms, the platform could create opportunities for manufacturers by generating new product ideas and work. It also enabled individual inventors to receive long-term revenue from their ideas without investing significant economic capital or taking on the full risks of product development. Quirky's business model has since shifted towards licensing inventions to partner companies.

3. Intergenerational housing in care homes - CCAS Montpellier

To reduce the isolation of many older residents, address the precarious housing situation of many students and create greater social cohesion in the neighbourhood, the Centre Communal d'Action Sociale (CCAS) of Montpellier implemented a low-rent intergenerational flat-sharing project in municipal care homes for older people, known in France as EHPADs. The project offers renovated former staff apartments

inside several nursing homes to around 15 students, depending on the year, at a moderate rent; the original project description reported rents of about EUR 190–290 per month. In exchange, students volunteer for at least three hours per week with residents.

Each month, students are offered a schedule of inter-generational activities, organised according to their availability and areas of interest, in coordination with the professional team of the EHPAD. The objectives are to provide very low-cost housing for students, develop a year-round intergenerational project and open nursing homes to their neighbourhoods by turning them into active intergenerational spaces. The students can share moments of conviviality with residents and discover the realities of life and work in these structures. For residents, the project offers opportunities 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 also supports the efficient management of CCAS real-estate assets. The rent collected can be reinvested in intergenerational workshops and activities, improving residents' quality of life and helping create social cohesion. The visibility of the project has also helped improve the image of nursing homes as places to live that are open to the neighbourhood. In this way, the project activates a chain of solidarity: apartments renovated for young people support students who, in turn, become involved with older residents.

4. Free language courses for foreigners - Millevoci

Millevoci was created in Fano, Italy, as a volunteer association offering free Italian-language teaching to foreigners from any country or social class. The association is made up mainly of volunteers, including former primary-school teachers, homemakers, professionals and young people. Its main goal is to facilitate integration between new and long-standing families, in order to improve quality of life for both foreign residents and native Italians. The municipality did not need to fund the association directly, apart from providing stationery and basic support.

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 system, and its digital structures, impoverish local cultural values and identities?
- Does the current system, and its digital structures, offer only one solution/few variations for all regions and cultures?
- Does the current system, and its digital structures, have a negative impact on the social well-being of the local community?
- Does the current system, and its digital structures, impoverish local economies?
- Does the current system, and its digital structures, absorb local non-renewable resources?
- Does the solution current system diminish, ignore or compromise local resources, regulations, or cultural representations?

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**
- Improve convenience and site attractiveness for users/customers with digital platforms to access physical assets. **example 2**
- 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.
- Offer the access rather than the ownership of DE systems* to extend it even to low and middle-income local entrepreneurs. **example 3**
- Complement offers for DE systems* with all-inclusive services and products 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 creating services in the same place where they will be used. **example 4**
- Favour any development that enhances the 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 (involving the weak and marginalised). **examples 6**
- Renew/ regenerate industrial, domestic and urban dismissed products and materials. **examples 7**
- Renew/ regenerate industrial, domestic and urban dismissed products and materials. **example 8**

- Adopt/ promote system using regenerated natural, local resources.
- Respect/ enhance locally based activities enterprises.
- Respect and encourage cultural identities and diversities. **example 9**

Examples

1, 2. Access-based solar kiosks - Solarkiosk



Fig. 3.57 Solar Kiosk⁷⁹

⁷⁹ Vezzoli, C., Garcia, B. and Kohtala, C. (2021) Design sustainability for all: the design of sustainable product-service system applied to distributed economics. S.I.: SPRINGER NATURE.

Solarkiosk targets local entrepreneurs, especially women, for the provision of services through solar-powered E-HUBB kiosks. Rather than requiring operators to purchase the equipment outright, Solarkiosk pre-finances each kiosk and maintains the technical setup, while local operators manage the system and its services. Customers pay only for the services they need, such as device charging, internet access, water purification, printing or scanning. The model reduces the initial investment and technical burden for local entrepreneurs, giving them access to productive infrastructure and service-based business opportunities.

3.1 Local organic street market - Bio-mercato

Bio-mercato was a street market in Milan, Italy, promoted by VAS (Verdi Ambiente e Società), an environmental association supporting healthy and environmentally responsible lifestyles. The market gathered small local organic producers and eco-sustainable artisans from Lombardy and nearby regions. Around 45 stands sold certified organic products such as vegetables, fruit, cheese, cured meats, honey and olive oil. Crafts, untreated cotton clothes, herbal products and books on cooking and natural medicine were also sold. The stands were assembled by the retailers, who also cleaned the area afterwards.

VAS coordinated the work of producers, retailers, artists, craftspeople and volunteers. It also obtained the necessary permits from the public administration, supervised the market and communicated the initiative to the public through press releases. Bio-mercato promoted a healthier urban lifestyle by enabling city inhabitants to be better informed and to buy organic food directly from farmers. It also supported local producers, promoted a conviviality often absent from city supermarkets and reconnected city and countryside.

The market, with limited support from public institutions, provided an alternative retail channel for small organic producers and retailers. Farmers could receive better value for their work, while consumers could find organic food at competitive prices compared with specialist shops or supermarkets. Organic production, avoiding genetically modified seeds and synthetic pesticides and following organic and seasonal cultivation techniques, can reduce pollu-

tion, preserve the landscape and safeguard biodiversity. Since much of the food was grown locally, reduced transport also helped lower the environmental impact of the food chain. The Bio-mercato model continues in similar short-supply-chain markets in Milan, such as the Milan Earth Market and other farmers' markets that connect urban consumers directly with nearby producers.

3.2 Solidarity purchasing group - GAS Baggio

A Solidarity Purchasing Group (Gruppo d'Acquisto Solidale or GAS in Italian) responds to the need for a different way of consuming: buying collectively and democratically. Members reconsider their consumption habits and purchase everyday products together, giving preference to local, seasonal and organic products, small local producers and social cooperatives, direct contact with suppliers' production sites, and cost reduction through de-intermediation. The first Italian GAS was founded in Fidenza in 1994; today, groups such as GAS Baggio in Milan continue this model.

GAS Baggio organises collective purchases to support a more sustainable lifestyle and reduce environmental impact. Members choose small, local producers who respect people and the environment, and establish direct relationships with them. By buying in larger quantities and bypassing several links in the distribution chain, the group supports local producers and helps reduce pollution and energy consumption caused by transport.

3.3 Organic food box and shop - Ökosahver



Fig. 3.58 The ecopantry⁸⁰

Ökosahver, now operating as Sahver, is an Estonian organic shop and wholesaler based in Tallinn. It was founded by a small circle of people who wanted easier access to healthy and organic food. Its original service operated in Tallinn and Tartu and focused on controlled organic products that were then difficult to find locally.

One of its most important early offers was a weekly “food box”, containing around ten types of food supplies, mainly vegetables, but also products such as honey, bread and aromatic herbs. The food box was intended to satisfy the weekly needs of a family of four and could be ordered once a week by telephone or online. Products came mainly from local organic producers. Customers received information about the contents of the food box by email and could also read it on the Ökosahver website.

Ökosahver also operated as a shop, selling products such as pasta, rice, sugar, olive oil, vegetables, cleaning products and preserves. The organisation supported small organic producers through food distribution and by providing information about organic products. In this way, it promoted more sustainable agriculture, biodiversity and local production. Local distribution also helped reduce transport and the environmental impact associated with it.

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

3.4 Shared local-food distribution - Skye and Lochalsh Food Link



Fig. 3.59 Van Group's Food van⁸¹

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

Skye and Lochalsh Food Link is a Community Interest Company in Scotland that promotes the increased use and production of local food. It was initiated in 2000 by local producers who decided that, rather than delivering every product themselves, they would share a van running a regular route to collect produce from producers and deliver it to customers. The Food Link Van connects local producers, caterers, retailers and consumers, distributing local produce across the Skye and Lochalsh area.

By sharing transport, producers could reduce individual delivery journeys, save fuel and make local food more widely available. The service helps support the future of local food producers by distributing their goods and promoting fresh, locally produced food. It also contributes to important aspects of community life, including the local economy, environmental sustainability and the health benefits of fresh local produce.

3.5 Open source (copyleft) software - Mozilla Public License



Fig. 3.60 Copyleft symbol⁸²

Copyleft is a wordplay on copyright. It refers to the practice of using copyright law to guarantee that a work, and modified versions of that work, can be used, studied, copied, modified and redistributed, provided that the same freedoms are preserved in redistributed versions. In this sense, copyleft does not reject copyright; rather, it uses copyright licensing to impose reciprocal conditions on the use and distribution of a work.

Copyleft is most commonly implemented through licences applied to intellectual property such as software, documents, music or art. Whereas copyright law automatically restricts the right to copy and redistribute an author's work, a copyleft licence grants these rights on condition that derivative works are released under the same or compatible terms. For this reason, copyleft licences are also known as reciprocal licences.

One example is the Mozilla Public License (MPL), a free and open-source software licence originally developed for Mozilla software. Version 1.0 was written by Mitchell Baker in 1998, when she was working as a lawyer at Netscape Communications Corporation; the current version is MPL 2.0. The MPL is often described as a weak or file-level copyleft licence, because changes to MPL-licensed files must remain under the

⁸² Wikipedia (2022). Available at: <https://es.wikipedia.org/wiki/Copyleft#/media/Archivo:Copyleft.svg>

MPL, while larger works may combine MPL-covered files with code under other licences. This makes it less restrictive than the GNU General Public License, while still preserving access to modified MPL-covered source files.

4. Adopt a sheep - La Porta dei Parchi



Fig. 3.61 Making cheese with sheep milk⁸³

⁸³ La Porta dei Parchi (2022) Available at: <https://laportadeiparchi.com/>

La Porta dei Parchi, a bio-agritourism farm in Anversa degli Abruzzi, Italy, promotes the initiative Adotta una Pecora (“Adopt a sheep”). The service responds to consumers’ growing interest in the origin, processing and raw materials of food by allowing them to support pastoral production more directly. It also gives the farming business a sales method that safeguards local traditions, pastoral knowledge and the environmental resources of the Abruzzo mountains.

The user pays an annual contribution, currently including options between €75 and €190, which acts as an advance payment to support the costs of shelter, labour and animal feed. In exchange, the user receives prod-

ucts from the farm and can follow the life of the adopted sheep and the farmer's activities, either remotely or by visiting the farm. Products may be delivered to the user's home or collected at the farm. Adopters can also take part in pastoral events such as sheep-shearing, transhumance, guided walks and workshops.

This initiative helps safeguard Abruzzo shepherd communities and their knowledge, which risk being lost. It gives farmers greater economic security, while consumers receive traceable products and learn about a rural context that is often distant from urban everyday life. The initiative also claims a saving of more than 12% compared with the market value of similar products.

5. University incubators for popular cooperatives - ITCP/UFPR

Since the late 1990s, Brazilian universities have developed a network of Technological Incubators of Popular Cooperatives (Incubadoras Tecnológicas de Cooperativas Populares, ITCPs). These university-based programmes aim to generate work and income for low-income groups, supporting local development within the framework of the solidarity economy. They do so by disseminating technical, scientific and organisational knowledge produced within universities.

One example is the ITCP of the Federal University of Paraná (ITCP/UFPR), created in 1999 as a university extension programme. Its work is based on self-organisation and collective work, supporting unemployed people and workers in the informal sector to organise themselves into cooperatives, associations and other solidarity-economy enterprises. The incubator works across several fields, including pedago-

gy, psychology, economics, administration, law, technology, engineering and design.

The ITCP organises training on cooperative principles, administration, accounting, technology and design at different levels. It also supports economic-feasibility analysis and enterprise formalisation. The incubation process may include: understanding the community's resources and problems; identifying skills and proposals; training on legal, structural and administrative aspects of cooperatives; feasibility studies; literacy, mathematics and specific technical education; and advanced support for marketing, communication, market access and administrative regularisation.

Some cooperatives supported in the context of ITCP/UFPR include COEMBRA, COPTECH and COOP-ERMANDI. The social benefits arise from the development of the communities involved: recognising people's skills and management capacities, creating job opportunities and improving living conditions.

6.1 Affordable rental housing - Dar Casa

Dar Casa is a housing cooperative in Milan that responds to the housing needs of families and people who would otherwise struggle to access the private rental market. Founded in 1991 as an indivisible-property cooperative, it cannot sell its homes, but only rent them.

The system works as follows:

1. Dar Casa obtains unused or degraded public housing, originally through agreements with ALER and later also with the Municipality of Milan, at controlled rents and with the obligation to renovate the dwellings.



Fig. 3.62 Darcasa refurbished and assigned apartments as part of the Quattro Corti redevelopment project, Milan⁸⁴

2. The cooperative renovates the flats, supported by grants, social lending and other forms of funding, and then assigns them to members who meet the requirements for social or moderate rent.
3. The rent paid by residents covers the lease paid by the cooperative, together with a share of the renovation and management costs.

Dar Casa's housing is therefore offered below free-market levels; one current profile reports an average rent of about €60/m² per year, equivalent to around €300 per month for a two-room flat, excluding service charges.

The model is socially functional because it provides decent and affordable housing for people who would otherwise be excluded. Housing, like work, can support integration into society, offering people a more stable, secure and dignified life and enabling them to become part of a community. The renovation of unused or degraded buildings also gives new life to existing housing stock, reducing the need for new construction on undeveloped land. In this way, Dar Casa links social and environmental aims: it addresses housing exclusion while recovering existing buildings and supporting more inclusive neighbourhoods.

⁸⁴ Dar Casa (2022). Available at: <https://www.darcasa.org/stade-ra-quattro-corti/>

6.2 Ecovillage and sustainable tourism - Torri Superiore



Fig. 3.63 Solar panel in the Torri Superiore eco-village⁸⁵

⁸⁵ Vezzoli, C. (2010) System Design for Sustainability: Theory, Methods and Tools for a Sustainable 'satisfaction-system' Design. Maggioli.

Torri Superiore is a restored medieval village near Ventimiglia, in Liguria, Italy. The village is made up of over 160 vaulted rooms, connected by an intricate maze of staircases, terraces and alleys. After decades of abandonment, the Associazione Culturale Torri Superiore was founded in 1989 to preserve the village and turn it into an ecovillage and cultural centre. Today, the village has been restored and is open to ecotourism, courses, meetings and environmental-education programmes. The ecovillage includes resident and non-resident members, while guests are invited to follow ecological principles in order to reduce their environmental impact. Community life is based on shared choices and the use of consensus methods. The association owns part of the village, while other areas are owned by individuals, some of whom live there seasonally. The community organises cultural activities, welcomes guests and supports the gradual integration of new members. Torri Superiore combines ecological restoration, community life, hospitality and local production. The Casa per Ferie hosts visitors, volunteers and groups interested in ecology, sustainability and community living, and

helps sustain the cooperative activities of the village. Agricultural activities include vegetable growing, olive cultivation and small-scale animal husbandry. Torri Superiore also offers theoretical and practical activities related to sustainability, community life, self-care, the local area and crafts. Its aims include the sustainable recovery of the local area through ecological architecture and agriculture, the development of sustainable tourism, the dissemination of knowledge on environmental sustainability, and the sharing of experiences, decisions and childcare.

7.1 Reuse and work-integration services - Di Mano in Mano



Fig. 3.64 The model of Di mano in mano⁸⁶

“Di Mano in Mano”, based in Milan, has its roots in the Villapizzone and Castellazzo community experiences, linked to the “Associazione Mondo di Comunità e Famiglia”. These communities consisted of families open to hosting children and adults in difficulty. The cooperative was created to support the communities through house clearances, reuse, recycling, restoration and green-area maintenance. House clearance became its main activity: furniture, objects, books and clothes were recovered, restored where appropriate, and sold through second-hand markets and shops.

⁸⁶ LeNS (2022). Available at: <http://www.lenslab.polimi.it>

Together with Caritas Ambrosiana and Caritas Como, Di Mano in Mano also promoted the Arriviamo project, which provided housing for people in difficulty.

The affiliated cooperative Di Mano in Mano Solidale focused on activities such as gardening, used-clothing collection, house clearances and small maintenance. Di Mano in Mano Servizi provided management and financial support to families belonging to the communities and to a small number of external users. These services reduced costs and helped people use their time more effectively, while meeting practical needs. Over time, Di Mano in Mano developed into a professional cooperative while preserving its original social purpose.

Today, Di Mano in Mano continues to work in recovery, valuation, restoration, rental and sale of antiques, modern design and second-hand goods, through physical shops and online channels. Its sustainability approach combines environmental and social aims: waste is treated as a loss of material value and as a collective problem, while reuse and recycling recover goods that would otherwise be discarded. The organised activities also create work and training opportunities, including for young people and vulnerable people. The cooperative is self-financed through its services and reinvests income in its activities and social mission. Its model therefore combines reuse, service provision, employment inclusion and community support.

7.2 Open-source plastic recycling - Precious Plastic

Precious Plastic is an open-source project that shares designs, instructions and knowledge for building small-scale machines to recycle plastic waste and produce new products. The basic machines include a shredder, extrusion machine, injection machine and compression machine. Together, they enable users to shred plastic waste into small flakes, melt it and transform it

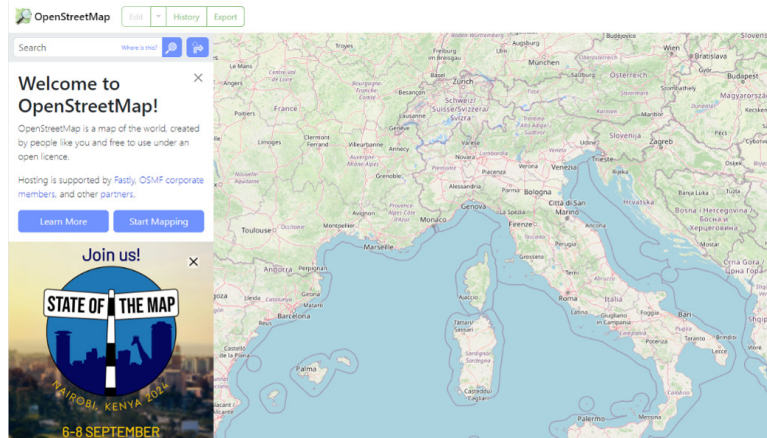
into new objects. The project also provides an online community and marketplace through which users can exchange knowledge, share solutions, find machine builders and sell recycled products or equipment. In this way, Precious Plastic supports a distributed recycling ecosystem in which people can build, adapt and improve recycling machines, contribute to product designs and start local initiatives based on plastic-waste transformation.

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

In Egypt, annual date-palm pruning produces large quantities of leaves. These leaves have tough, woody midribs that can be transformed into planks or board-like elements with mechanical properties comparable to some imported woods, such as spruce and beech. They can be used to make screens, tables and other furniture. The material can be used directly, or shaped into boards for furniture production using local technologies. Researchers at Ain Shams University have developed furniture and building components made from date-palm midribs. The materials used are renewable and can be processed with appropriate technologies. Wood is relatively scarce in Egypt and many African countries, and often has to be imported, with environmental costs linked to transport. In these areas, however, date palms are widely available and can provide an alternative material to wood. This can help avoid some of the environmental and economic costs associated with purchasing imported timber.

9. Map Created by People - OpenStreetMap

OpenStreetMap (OSM) is an open mapping project built and maintained by a global community of map-



87 OpenStreetMap.
Available at: [https://
www.maptiler.com/](https://www.maptiler.com/)

Fig. 3.65 OpenStreetMap Website⁸⁷
©OpenStreetMap openstreetmap.org/copyright

pers who contribute data on geographical features. Emphasising local knowledge, contributors use aerial imagery, GPS devices and low-tech field maps to improve the accuracy and currency of the data. The community is diverse and includes enthusiast mappers, GIS professionals, engineers and humanitarians. As an open data platform, OSM allows users to use, modify and share its data freely, provided that proper attribution is given and derivative databases are shared under the same licence.

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

The following section presents a set of strategies and related guidelines to support the design of Distributed Economy systems based on 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 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

Grameen Bank is a microfinance organisation founded in Bangladesh. It provides small loans, known as microcredit, to unemployed people, poor entrepreneurs and others living in poverty who are not served by regular banks. These individuals often lack collateral, steady employment and a verifiable credit history, and therefore cannot meet the minimum requirements for access to traditional credit. The system is based on the idea that poor people have skills that are under-utilised. The bank also accepts deposits and provides other financial services. Grameen Bank and its founder, Muhammad Yunus, were jointly awarded the Nobel Peace Prize in 2006.

2. Open-source electronics platform - Arduino

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards can read inputs — such as light on a sensor, a finger on a button or a message from an online platform — and turn them into outputs, such as activating a motor, turning on an LED or publishing something online. Users can tell the board what to do by sending a set of instructions to the microcontroller on the board, using the Arduino programming language and the Arduino Software (IDE). Arduino can be used in the distributed production and prototyping of electronic hardware.

It is used in a wide range of project areas, including DIY 3D printers, robotics, the Internet of Things and wearables. Its easy-to-use interface, relatively low cost, compatibility with a wide range of platforms and the wealth of information, examples and code provided by the community make it accessible to a broad range of users developing complex projects.

3. Pay-as-you-go solar home systems - Bboxx



Fig. 3.66 Part of a Bboxx solar home system presented by an employee⁸⁸

⁸⁸ Vezzoli, C. et al. (2018) Designing Sustainable Energy for All. Cham: Springer International Publishing (Green Energy and Technology).

Bboxx, founded in 2010, provides decentralised energy solutions in several African markets, selling its own solar home systems (SHS) and related accessories. These systems are supported by Bboxx Pulse®, a digital platform used to monitor energy use, payments and system performance. Customers usually make an initial payment and then pay regular instalments, often through mobile money. In Kenya, current advertised packages start from about USD 0.90–1.00 per day. After full repayment, usually within three years, the solar system is owned by the customer. Installation, maintenance and repair are included in the offer and provided through Bboxx's local service network. Some current contracts also include longer-term maintenance support.

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. Solar-powered service kiosks - Solarkiosk

Solarkiosk targets local entrepreneurs, especially women, for the provision of energy services through solar-powered stations. The company designs and installs the E-HUBB, a modular solar kiosk described as a business-in-a-box, equipped with photovoltaic panels, and recruits, trains and supports local entrepreneurs to manage the system. Due to the modular configuration of the station, operators can provide a wide range of services, such as device charging, internet connectivity, water purification, printing, copying and scanning. To date, approximately 250 E-HUBBs have been deployed in 15 countries, reaching around 5 million people.



Fig. 3.67 Example of an E-HUBB structure provided by Solarkiosk to local entrepreneurs⁸⁹

⁸⁹ 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.

2. Membership-based fabrication workshops - TechShop



Fig. 3.68 Techshop workshop space and tools⁹⁰

⁹⁰ LeNS International (2022). Available at: <http://www.lenslab.polimi.it>

TechShop was a chain of membership-based co-working spaces and workshops that provided access to industrial tools and equipment.

Its former CEO, Mark Hatch, described TechShop as a “membership-based DIY fabrication studio and workshop” that was “democratising access to the tools of the industrial revolution”. The BBC described it as a growing network of open-access manufacturing workshops.

Members could use equipment including milling machines and lathes, laser cutters, sheet-metal equipment, welding equipment, an indoor automotive work bay, woodworking equipment, a 4' × 8' CNC ShopBot router, plastics-working equipment, hand tools, 3D printers, CNC vinyl cutters, sewing machines and design software.

Membership fees varied by location and period, but were commonly reported at around USD 150–200 per month. Membership gave users access to more than USD 1 million worth of advanced machines, tools, software and professional equipment at each location.

3. Shared food-production facility - KitchenTown



Fig. 3.69 KitchenTown equipment and spaces⁹¹

KitchenTown is a shared food-production facility and incubator in San Mateo, California, serving small food producers and start-ups that make locally produced, small-batch products. Its Bay Area facility has more than 20,000 square feet of shared production space and provides access to specialised equipment for production, packaging and storage. It is aimed mainly at food start-ups and makers looking to scale, who can use KitchenTown's commercial kitchen and scale-up facilities rather than investing in their own. They also supports makers with product development, machinery operation, production and shipping. Users can schedule time to use the facilities and receive support from staff in producing their products.

91 KitchenTown (2022)
Available at: [https://
kitchentowncentral.
com/](https://kitchentowncentral.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. Solar and hybrid mini-grid services - OMC Power

OMC Power offers renewable energy solutions to telecommunication companies, businesses and communities in rural off-grid areas. The company builds, owns and operates solar power plants and smart mini-grids, providing energy without requiring

customers to invest in the infrastructure. Customers pay according to consumption, while OMC Power retains ownership of the energy system and provides operation and maintenance. It also provides design, installation and digital energy-management services, allowing systems to be configured, monitored and optimised according to the needs of telecom clients, businesses, public facilities and rural communities. Its mini-grids supply electricity to telecom towers, rural businesses, public services and households, helping replace diesel, kerosene and other less sustainable energy sources. The company currently reports around 350 solar power plants in India.

2. Pay-as-you-go solar home systems - ZOLA Electric

ZOLA Electric offers solar home systems (SHS) to households and businesses in low- and middle-income contexts in Africa. The SHS packages include the hardware required to generate and store solar energy—solar panels, batteries and wiring—together with energy-using products such as LED lights, phone chargers and other low-power appliances that meet everyday energy needs. Customers pay through a pay-as-you-go model, often using mobile money, which spreads costs over time and facilitates access to energy. ZOLA Electric retains responsibility for the system and related appliances during the service period, including maintenance, repair and customer support, thereby reducing both the initial investment and unexpected expenses for the customer. Furthermore, the company trains and supports local sales agents, installers and customer-service staff, fostering local employment and technical capacity. Its model combines distributed renewable-energy technology, financing, installation and after-sales support.

3. Pay-as-you-go computing model - Microsoft

Microsoft filed a patent application for a pay-as-you-go computing model in which a computer has scalable performance components and selectable software and service options. The scalable components may include the processor, memory and graphics controller, while software and services may include word processing, email, browsing and database access. A user interface allows users to select individual performance levels and pay only for the selected services and performance levels that correspond to the task being performed.

An administrator may use a similar interface to set performance levels for each computer in a network, allowing performance and cost to be adapted to users' requirements. This pay-per-use model could be applied in distributed economies, such as distributed information (DI), distributed software (DS) and distributed design (DD), where information, software or design activities are carried out using a PC. The service could be provided in the form of software and hardware bundles for different purposes, such as office work, gaming and browsing.

4. On-demand manufacturing marketplace - Xometry

Xometry is an online marketplace that connects buyers with manufacturers, factories and suppliers, offering access to available production capacity for companies of different scales. A buyer uploads a project file to Xometry's website and receives an instant quote with price, lead time and manufacturability feedback. Upon approval by the buyer, Xometry places the project with suppliers whose capabilities and

availability correspond to the project needs.

Xometry manages production, material procurement, delivery and payments, and works with vetted manufacturing partners to ensure quality and on-time delivery. Its network supports processes including CNC machining, sheet-metal fabrication, 3D printing, injection moulding, urethane casting, die casting, laser cutting, plasma cutting and waterjet cutting.

Guidelines for optimising 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). **example 3**
- Make the DE hardware manufacturer offers S.PSS either alone or in a joint venture with other stakeholders. **examples 4**

Examples

1. Shared food harvesting and processing - Pick Your Own



Fig. 3.70 top: Pick Your Own farms and activities⁹²

⁹² Vezzoli, C., Garcia, B. and Kohtala, C. (2021) Design sustainability for all: the design of sustainable product-service system applied to distributed economics. S.I.: SPRINGER NATURE.

The pick-your-own model allows home or commercial users to harvest fruit and vegetables directly from local farms. PickYourOwn.org lists pick-your-own, or U-pick, farms in the United States, Canada, Britain, Australia, New Zealand, South Africa and other countries, and also provides harvest calendars showing when different crops are usually available. Home or commercial users can pick fresh produce from these farms, or use produce from their own farms and gardens, and process it into canned, bottled or packaged products using shared, community or commercial kitchens and canneries. These facilities may be used to produce food for personal use or, where licences and regulations allow, for sale.

Some facilities also provide information, training and opportunities for users to meet, collaborate and learn from each other. Common payment methods include paying by period, by produced unit or by process, or a combination of these.

2.1 Ethical finance and credit - Banca Etica

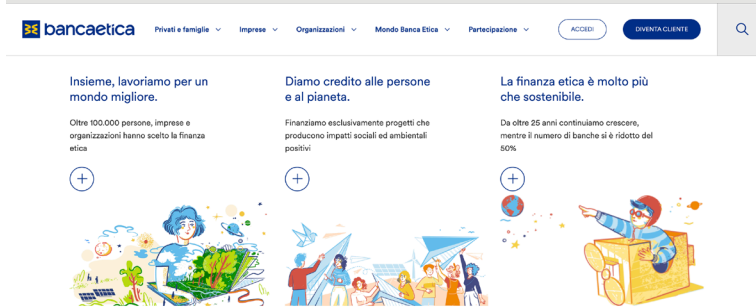


Fig. 3.71 Banca Etica offering page⁹³

The Italian Banca Popolare Etica aims to realise the idea of a bank as a meeting point for savers who share the need for responsible and conscious management of their money. They also share the idea of a sustainable development model, in which the creation and distribution of wealth are founded on the values of solidarity, transparency and the pursuit of the common good. Banca Etica recognises that social transformation also depends on the transformation of productive systems. For this reason, it finances projects concerned with social and environmental sustainability and facilitates access to credit for people and organisations that want to develop projects in these areas.

⁹³ Banca popolare Etica (2026). Available at: <https://www.bancaetica.it/>. Used for educational, non-commercial purposes.

2.2 3D printer leasing and rental - EOS

EOS is a provider of industrial 3D printing systems, materials, software and services for metal and polymer additive manufacturing. In addition to selling new systems, EOS offers leasing and rental models for its manufacturing systems, allowing companies to access 3D printing equipment without purchasing it outright. These models can be used to expand production capacity or scale qualified processes while preserving financial flexibility.



Fig. 3.72 EOS M 290 industrial metal 3D printing system⁹⁴

⁹⁴ EOS (2026). Available at: <https://www.eos.info/press-media/press-center/media>. Used for educational, non-commercial purposes.

EOS states that leased or rented systems can include comprehensive service support comparable to that provided for newly purchased systems. The company also offers financing options, training, technical services and support for system operation.

In addition, EOS sells pre-owned metal and polymer systems that are refurbished with original EOS spare parts, updated with the latest available software and quality assessed before resale.

3. Pay-as-you-go mini-grid services - Husk Power

Husk Power provides energy solutions by installing and operating mini-grids, and by wiring rural communities to deliver electricity. It originally developed biomass plants powered by rice husk, sourced through partnerships with local farmers. It has since diver-



Fig. 3.73 Biomass collection and system implementation⁹⁵

sified towards solar and hybrid mini-grids as part of a distributed generation (DG) or distributed energy resources (DER) model. Husk Power designs, builds, owns and operates mini-grids that serve households, businesses and community services in off-grid and weak-grid areas. Customers access electricity through a pay-as-you-go service. Husk Power retains ownership of the mini-grid infrastructure and provides operation and maintenance, while employing local staff for sales, technical support, security and customer service. The model also shows horizontal integration, because electricity supply is combined with related distributed services, including appliance sales and financing, digital smart-metering, e-mobility solutions, and support for agricultural value chains such as agro-processing and cold storage.

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

4.1 Digital fabrication matchmaking platform - 100kGarages

ShopBot Tools designs, manufactures and distributes CNC routers for milling, drilling and cutting wood, plastic, aluminium and other materials. Its CNC routers are commonly used in fab labs, schools, maker-spaces and community organisations. 100kGarages is an online platform started by ShopBot Tools in collaboration with Ponoko. Through 100kGarages, people with designs, CAD files or project ideas can connect with local fabbers through an online match-making service, receiving support for design and manufacturing with CNC routers, laser cutters, 3D printers and other digital fabrication tools. In short, 100kGarages helps people find one another, learn from one another and turn ideas into physical objects. ShopBot also offers technical support, training resources and finance or leasing options for its products.

4.2 Co-creation microfactory - FirstBuild

FirstBuild is a project in which online and local community members can design products and help solve engineering challenges. It includes an online platform where the community can share ideas and co-create home appliances. There is also a microfactory and open makerspace in Louisville, Kentucky, which provide advanced manufacturing techniques and rapid prototyping tools.

Products can be developed, tested and made in small batches in this space, which is open to the public. The microfactory includes areas for brainstorming and product demonstration, prototyping, component fabrication and product assembly.

Guidelines for delinking payment from hardware purchases and resource consumption

- Offer pay x period, i.e. the cost is daily/ weekly/ monthly/yearly fixed. **example 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. Community garden plots – Parco Nord Milano

Parco Nord Milano offers social and recreational garden plots to adult residents of the municipalities belonging to the Park, for an affordable annual fee. Assignees are required to cultivate and care for the garden, keep common spaces clean, follow the Park regulations and collaborate with other users. The lease lasts six years and may be renewed once for the same period. The service facilitates participation and socialisation, fosters a sense of responsibility and care, and encourages mutual help and the exchange of knowledge.

2.1 In-store 3D printing service - MakerBot

MakerBot provided an in-store 3D printing service through its retail stores. Users, such as designers or makers who wanted to print a prototype or final product, or users without 3D modelling skills who wanted to print a purchased or free 3D model, could bring

a 3D file to a MakerBot store and have it printed by MakerBot staff. The service used in-store MakerBot Replicator 2 Desktop 3D Printers and included basic file checking through software, although MakerBot did not accept responsibility for problems arising from the design itself. Once the user brought the files to the store, the software calculated the print time and cost. The user was then contacted when the printed object was ready for collection. Prices were based on print time: less than 30 minutes cost USD 10, two hours cost USD 35 and six hours cost USD 100, while longer prints required a specific quotation.

2.2 Pay-as-you-go solar home systems - Azuri Indigo



Fig. 3.74 Solar panel installed on the roof of a rural settlement⁹⁶

⁹⁶ 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.

Azuri's Indigo system allowed customers to access a solar home system (SHS) with a low initial payment. The system included a small solar panel, battery, two LED lamps and a phone-charging unit with cables. Customers then paid through a pay-as-you-go model, buying weekly top-ups from local vendors or using mobile money to activate the system. The electricity generated by the solar panel provided several hours of lighting each evening and supported mobile phone charging. Over a typical period of around 18 months, regular payments allowed the

customer to pay off the system; after that, the customer could unlock it permanently or upgrade to a larger model.

Azuri also developed an “energy escalator” model, through which customers could progressively move from basic lighting and phone charging to larger systems capable of powering appliances such as radios or televisions.

3. Solar-powered connection centre - Solar Charge



Fig. 3.75 Example of individual solar-powered stations inside the café⁹⁷

The project provided a solar-powered connection centre and charging point, bringing low-cost access to IT services to the community of Alexandra, South Africa. The centre was installed at the Thusong Youth Centre and operated as a self-contained, off-grid solar container. Users paid only for selected services,

⁹⁷ Vezzoli, C. et al. (2018) *Designing Sustainable Energy for All*. Cham: Springer International Publishing (Green Energy and Technology).

such as internet access, mobile-phone charging, photocopying, scanning, faxing, money transfer or other kiosk-based services. Internet access was free for students and subsidised for adults, supporting education within the township. Ownership of the connection centre, charging point and included energy-using products (EUPs) was retained by Solar Charge. Each centre was managed by a trained administrator responsible for day-to-day operation and problem solving.

4. Local time bank - Passa-Tempo Milano Città Studi

The Time Bank Passa-Tempo of Milano Città Studi is part of the national system of Time Banks. These banks support a solidarity-based economy by valuing skills and knowledge without using money. Anyone can join the Time Bank, provided they are willing to offer something they are able to do. Members make themselves available, on request, according to their skills and competences. Exchanges are recorded in hours: those who provide a service earn time credits, while those who receive one spend them. The system is based on reciprocity and human relations rather than financial exchange or sanctions. At the Porta Vittoria headquarters, courses, events, debates and exhibitions are organised, providing opportunities for members to meet and spend time together.

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 world-wide-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 lantern rental and energy services - Ikisaya Solar Energy Group



Fig. 3.76 A family using a lamp provided by ISEG⁹⁸

Ikisaya Solar Energy Group (ISEG) is a self-help group in Kitui County, Kenya, established to provide solar-energy services to the population of Ikisaya and surrounding areas. The main services are lighting, mobile-phone charging and small IT services, de-

⁹⁸ 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>

signed for rural households and businesses without an electricity connection. The group was registered in 2011 and developed through the University of Oslo's Solar Transitions research project, which studied how basic energy services could be provided to low-income communities in an affordable and sustainable way. ISEG has operated pay-as-you-go and rental services for solar lanterns at the Ikisaya Energy Centre and through local agents in neighbouring areas. Kitui County includes underserved rural areas with limited electricity access, where many households have traditionally relied on kerosene for lighting. The area has strong solar irradiation, but high-quality solar products remain unaffordable for many low-income households.

1.2 On-demand 3D printing marketplace - Shapeways and Thangs



SHAPEWAYS

⁹⁹ Shapeways (2022). Available at: <https://www.shapeways.com>. Used for educational, non-commercial purposes.

Fig. 3.77 Shapeways sample 3D printed products and logo⁹⁹

Following Shapeways' acquisition of a majority stake in Thangs, artists and designers can upload their digital models to Thangs, sell downloadable files and list physical 3D-printed products that Shapeways manufactures on demand and ships to buyers. Thangs provides the marketplace and creator-shop functions,

while Shapeways supplies the industrial 3D printing and additive manufacturing services. Shapeways offers production in a wide range of materials, including plastics and metals, supported by digital tools for uploading, checking, preparing and pricing files before manufacturing. In 2025, Shapeways signed a long-term lease for a new European production and office facility in Eindhoven, the Netherlands, as part of its continued investment in European operations. Its services include global shipping, although availability, lead times and material options depend on the selected process and destination. The main offer for designers is therefore a complete package for selling products on demand, without directly managing production equipment, inventory or fulfilment. Designers can receive payment when customers purchase their products, after the costs of printing, handling and shipping have been deducted. Users can also upload their own files directly to Shapeways and pay for 3D printing and delivery according to the selected material, production requirements, quantity and shipping costs. These costs are calculated through Shapeways' online quotation system, which supports orders ranging from single parts to larger production runs.

2.1 Distributed manufacturing network - Treatstock

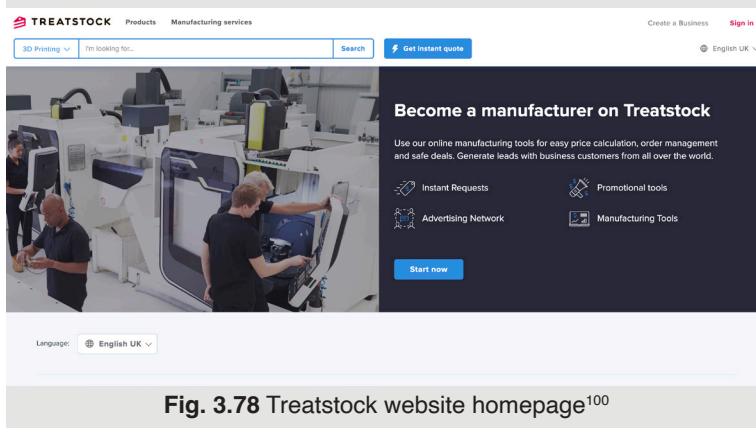


Fig. 3.78 Treatstock website homepage¹⁰⁰

¹⁰⁰ Treatstock (2026). Available at: <https://www.treatstock.co.uk/>. Used for educational, non-commercial purposes.

Treatstock is an online manufacturing service platform that offers a range of decentralised manufacturing services, including 3D printing, CNC machining, injection moulding and laser cutting. It operates through a network of manufacturing service providers, enabling users to order custom parts and products without owning the machines themselves. The company facilitates transactions between machine owners and users who want to make 3D models, prototypes or other custom products. Owners of 3D printers, CNC machines or cutting equipment can join the platform, register their machines and offer manufacturing services to customers locally or internationally. Customers can upload their files, compare available suppliers, receive online quotations and choose whether to have the finished product collected or delivered.

2.2 Pay-as-you-go solar micro-grid - SharedSolar

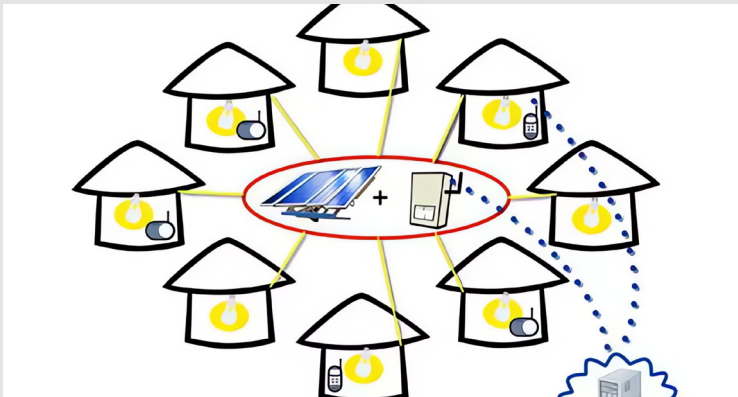


Fig. 3.79 Sample scheme of Shared Solar infrastructure and products within a village¹⁰¹

The Shared Solar model offers off-grid rural villages a decentralised solar micro-grid that connects households and small businesses to a local solar station. Users pre-pay for electricity in flexible amounts, with no monthly fee, through local agents, local stores or

101 State of the Planet, Columbia Climate School (2013). Available at: <https://news.climate.columbia.edu/2013/05/15/the-microgrid-solution/>

mobile-phone-based payments; earlier implementations also used scratch cards and SMS codes. The solar station, battery storage, smart meters and local distribution network are managed as shared infrastructure, while energy-using products are owned by the users. Additional services include installation, operation, maintenance and repair of the energy system. All stakeholders have access to real-time, contextual information. Customers can access their use and balance data, make payments and manage their consumption 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 platform. Generation and storage capacities are sized to match existing demand. As demand grows over time, capacity can be added through additional solar panels or other local energy sources. If the main grid arrives, the local distribution network and management system can be used without major modifications.

3.1 Open-source operating system kernel - Linux

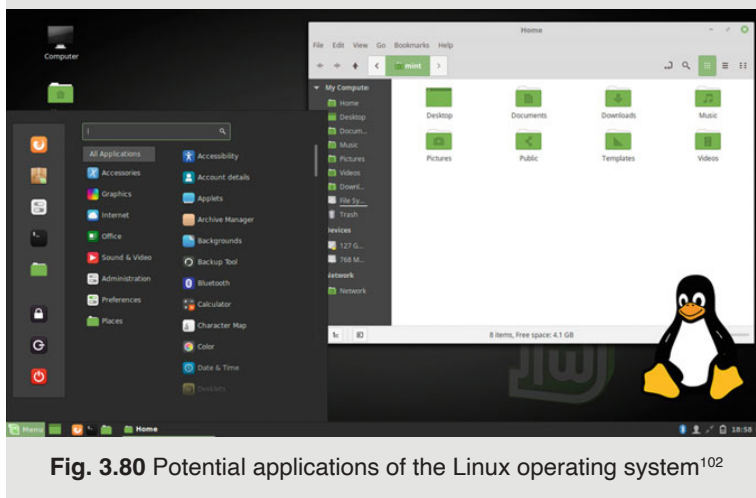


Fig. 3.80 Potential applications of the Linux operating system¹⁰²

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

Linux is a free and open-source operating system kernel used in a wide range of systems, including smartphones, personal computers, netbooks, super-computers, servers, embedded devices, home appliances and cars. The Linux kernel source code may be used, modified and distributed under the GNU General Public License version 2.0, which requires those who distribute modified versions to make the corresponding source code available to recipients under the same licence terms. Originally established as Open Source Development Labs in 2000, the organisation became the Linux Foundation in 2007 following a merger with the Free Standards Group. The Linux Foundation supports open-source communities through funding, infrastructure, services, events, training and collaborative project governance. Together, the Linux Foundation and its projects support the development of shared technologies used across many sectors.

3.2 Open vehicle design - Local Motors

Local Motors (LM) was a motor-vehicle manufacturing company focused on low-volume manufacturing, open-source vehicle design and distributed production through micro-factories. Its products included the Rally Fighter automobile, the Racer motorcycle, electric bicycles, tricycles, children's ride-on cars, radio-controlled model cars and skateboards. Some later vehicles and components also used large-scale 3D printing. The Rally Fighter was developed through co-creation techniques, with products designed collaboratively with end users and members of an online community.

The Local Motors website functioned as a community platform for vehicle innovation. Designers, engineers, fabricators and enthusiasts could submit ideas, discuss design, engineering and production issues, receive feedback and develop proposals collaboratively. Selected projects could move from online co-creation



Fig. 3.81 Example of a co-created open-source car developed by Local Motors¹⁰³

to physical production in Local Motors micro-factories. The micro-factory was also open to customers: using tools, parts and an interactive online build manual, customers could participate in constructing their own vehicle with support from the Local Motors team. Local Motors operated micro-factories in the United States and explored the expansion of this model to other locations. Its licensing model was based on Creative Commons-type principles: contributors retained recognition for their original work, while commercial rights and compensation mechanisms were defined when community contributions were incorporated into products sold by the company. When co-created products were commercialised, a share of revenue could be reserved for contributors according to their level of contribution. Similar approaches to open or distributed vehicle production have also been pursued in recent years by projects such as XYZ CARGO, which applies open-source, modular and locally produced design principles to cargo bikes.

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

4.1 MSDS Method for System Design for Sustainability

4.2 Tools 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.lenslab.polimi.it.

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	- Analyse project proposers and outline the intervention context - Analyse the context of reference - Analyse the carrying structure of the system Analyse cases of sustainable best practiced Analyse 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

104 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.

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)¹⁰⁴. 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:

- Sustainable Product Service Design Toolkit (Miro)
 - Analyse Existing System & Set Priorities – S.PSS
 - Sustainability Design Orienting Scenario
 - Idea Board – S.PSS
 - Innovation Diagram - S.PSS
 - Concept Description Form - S.PSS
 - System Map - S.PSS
 - Interaction Table
 - Interaction Storyboard
 - Concept Evaluation – S.PSS
 - Radar – S.PSS
- Sustainability Design-Orienting (SDO) toolkit
- Stakeholders Motivation and Sustainability Table
- Satisfaction Offering Diagram
- Animatic for S.PSS and DE
- E.DG - Estimator for Distributed energy Generation

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 the tool consists of;
3. The 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 Sustainable Product Service System Design Toolkit (Miro)

Aim

The objective of the *Sustainable Product Service System Design Toolkit (Miro)* is to create an easy way for designers and researchers to make tool selections when developing a sustainable product service system.

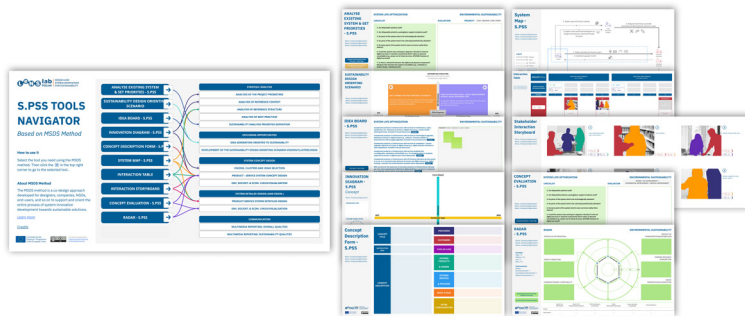


Fig. 4.1 Overview of the Sustainable Product Service System Design Toolkit

Components

The *Sustainable Product Service System Design Toolkit (Miro)* integrates the 10 tools presented in the previous chapters adding a Tools Navigator based on the MSDS method. It consists of:

- Existing System Analysis Checklists & Priorities - S.PSS
- Sustainability Design Orienting Scenario
- Idea Board - S.PSS
- Innovation Diagram - S.PSS
- Concept Form - S.PSS
- System Map - S.PSS
- Interaction Table
- Stakeholder Interaction Storyboard
- Concept Evaluation - S.PSS
- Radar – S.PSS

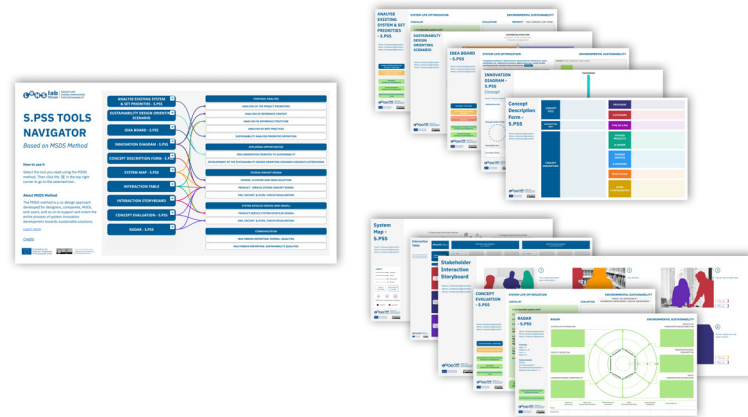


Fig. 4.2 Components of the Sustainable Product Service System Design Toolkit

Integration Into the MSDS Design Process

It can be used in different phases of the MSDS design process, as the ten tools can.

How to Use the *Sustainable Product Service System Design Toolkit*

Before Starting

Open an account on Miro (www.miro.com), then find LeNSlab Polimi templates on Miroverse website (<https://miro.com/miroverse/profile/lenslab-polimi>), and choose ***Sustainable Product Service System Design Toolkit (Miro)***. There are two ways to use this tool from the template page. One is to click “Use template”. Miro will create a new board with the tool in the logged-in account. Another one is to click the arrow on the right of “Use template,” then choose the existing board in the logged-in account; Miro will automatically duplicate the tool in the existing board.

“Sustainable Product Service System Design Toolkit” Guide

There is a “Tools Navigator” in the ***Sustainable Product Service System Design Toolkit (Miro)*** based on the MSDS

method. This navigator helps to choose the most suitable tool for the design process. On the right of this board is the tool navigator. The tools button is on the left, and each tool is linked to different phases on the right. The arrows are connected to the tools and design phases. For example, the System Map can be used in the Analysis of the Reference Structure, Product Service System Concept Design, and Product Service System Detailed Design phases by checking the two parts of the arrow links.

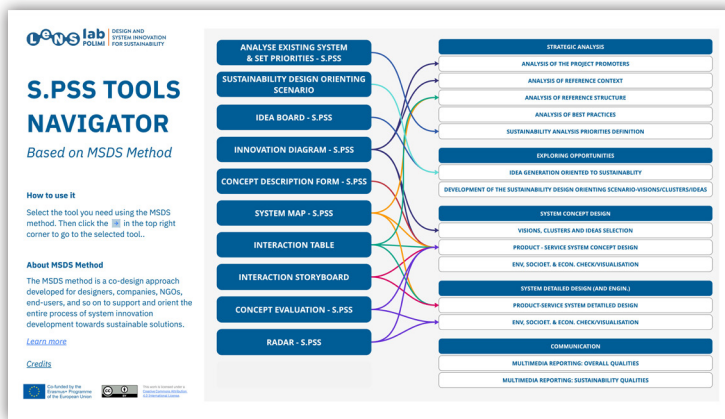


Fig. 4.3 Tools Navigator

For using the specific tools in the integrated one, please check the next sub-sections: Analyse Existing System & Set Priorities – S.PSS (1), Sustainability Design Orienting Scenario (2), Idea Board – S.PSS (3), Innovation Diagram – S.PSS (4), Concept Description Form – S.PSS (5), System Map – S.PSS (6), Interaction Table (7); Interaction Storyboard (8), Concept Evaluation – S.PSS (9), and Radar – S.PSS (10).

In this integrated tool, all the elements will be shared for different tools; for example, the labels created in the Innovation Diagram can be used in the Interaction Table. On the left side of each board is a navigator that helps one move through different tools in this integrated one. The tool can be used for a whole project and design process. It can also be used for a single phase of design.

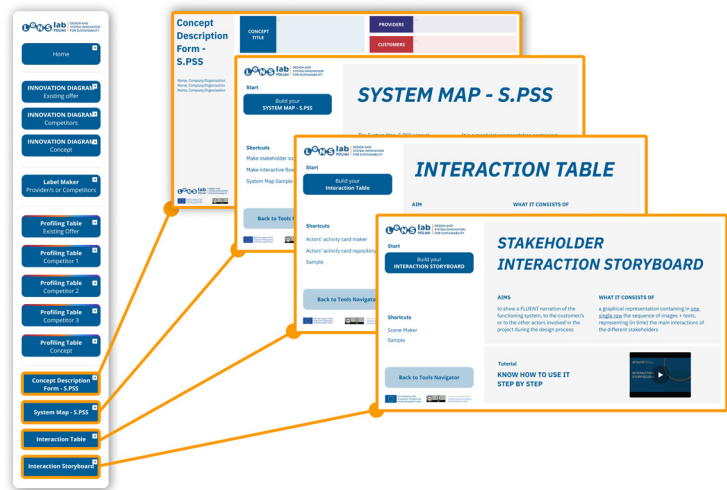


Fig. 4.4 Moving and sharing elements in the tool

Availability and Resources Required

The *Sustainable Product Service System Design Toolkit (Miro)* is an open-access tool freely available in the “Learning Resources – Tools” section of www.lenslab.polimi.it. A computer and a browser compatible with the Miro collaboration platform are required to access the toolkit; access to Figma and/or Photoshop is also recommended for using some of the tools it contains.

The toolkit requires around six hours to be completed. Each tool has its own time requirements; see the next sub-sections for details.

1) Analyse Existing System & Set Priorities – S.PSS (Miro)

Fig. 4.5 Overview of the Analyse Existing System & Set Priorities - S.PSS

Aim

The objective of the *Analyse Existing System & Set Priorities - S.PSS (Miro)* is to conduct a qualitative evaluation of the sustainability issues associated with each strategy (in the form of short reports), establish priorities among strategies to determine which ones can deliver the greatest environmental and socio-ethical benefits.

Components

This tool consists of:

2 sets of checklists, fields to write a qualitative assessment, and selector of priorities:

- Existing System Environmental Analysis & Priorities
- Existing System Socio-ethical Analysis & Priorities

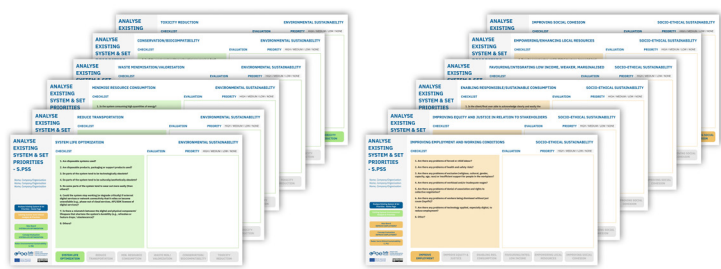


Fig. 4.6 Components of the Analyse Existing System & Set Priorities - S.PSS

Integration Into the MSDS Design Process

The *Analyse Existing System & Set Priorities - S.PSS (Miro)* is used within the Sustainability Analysis Priorities Definition phase to create the analysis and set the priorities of the existing S.PSS.

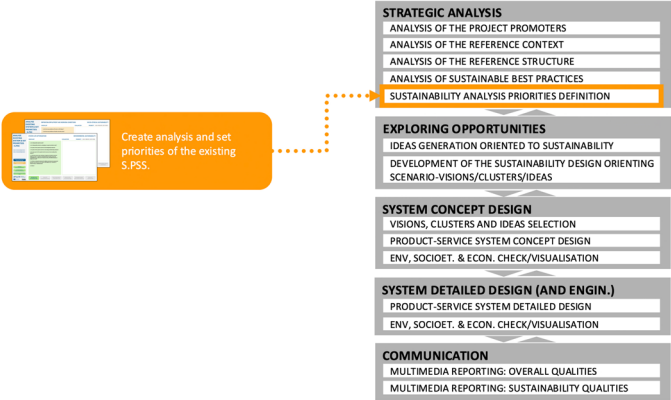


Fig. 4.7 Integrating Analyse Existing System & Set Priorities - S.PSS into MSDS design process

How to Use the *Analyse Existing System & Set Priorities - S.PSS (Miro)*

Before Starting

The first setup process is identical to the one described in

4.2.1. After installing Miro and finding LeNSlab Polimi in Miroverse, choose *Analyse Existing System & Set Priorities - S.PSS (Miro)*. As with all Miroverse templates, there are two ways to use this tool from the template page. One is to click “Use template”, which will create a new board with the tool in the logged-in account. Another one is to click the arrow on the right of “Use template,” then choose the existing board in the logged-in account; Miro will automatically duplicate the tool in the existing board.

This tool has a home board (Fig. 4.8) showing essential information, a video tutorial, and shortcuts for two main sections (Existing System Environmental Analysis & Priorities – S.PSS / Existing System Socio-ethical Analysis & Priorities – S.PSS). The navigation bar on the left of each board helps users move quickly between the different boards in the tool.



Fig. 4.8 The Home board of the Analyse Existing System & Set Priorities - S.PSS

There are two main sections in this tool. Each section has six different strategies available across different boards.

“Existing System Environmental Analysis & Priorities – S.PSS” Guide

Click the arrow on the top-right corner of the “Existing System Environmental Analysis & Set Priorities – S.PSS” but-

ton on the “Home” board. Move there and write down the designer’s name and organization to begin using the board. Next, select the environmental strategy to be addressed from the options available at the bottom of the board.

Fig. 4.9 Selection of strategies of the Existing System Environmental Analysis & Priorities - S.PSS

Then, write a qualitative assessment report of the existing system by entering the relevant information in the designated area. Use the questions provided in the checklist as prompts to guide the assessment and support the analysis.

Fig. 4.10 Area to write qualitative assessment report of the Existing System Environmental Analysis & Priorities - S.PSS

After completing the qualitative assessment report for the selected strategy, identify the priority level by highlighting the corresponding option in the evaluation bar located in the top-right corner of the board. Assign different colours to indicate the selected priority level.

ANALYSE EXISTING SYSTEM & SET PRIORITIES - S.PSS

Name, Company/Organisation
Name, Company/Organisation
Name, Company/Organisation

Analyse Existing System & Set Priorities - Home Page
Existing System Environmental Analysis & Priorities
New Board SYSTEM LIFE OPTIMIZATION
Concept Evaluation SYSTEM LIFE OPTIMIZATION
Sustainable Environmental Sustainability S.PSS

SYSTEM LIFE OPTIMIZATION

CHECKLIST

1. Are disposable systems used?
2. Are disposable products, packaging or support products used?
3. Do parts of the system tend to be technologically obsolete?
4. Do parts of the system tend to be culturally/aesthetically obsolete?
5. Do some parts of the system tend to wear out more easily (than others)?
6. Could the system stop working (or degrade critically) if external digital services or network connectivity that it relies on become unavailable (e.g., phase-out of cloud services, API/SDK licenses of digital services)?
7. Is there a mismatch between the digital and physical components' lifespans that shortens the system's durability (e.g., refreshes or feature drops / obsolescence)?
8. Others?

ENVIRONMENTAL SUSTAINABILITY

EVALUATION **PRIORITY** **HIGH** MEDIUM / LOW / NONE

2. High Quality food is disposed of...

SYSTEM LIFE OPTIMIZATION **REDUCE TRANSPORTATION** **MIN. RESOURCE CONSUMPTION** **WASTE MIN./ VALORIZATION** **CONSERVATION/ BIOCOMPATIBILITY** **TOXICITY REDUCTION**

Fig. 4.11 Selection of priorities of the Existing System Environmental Analysis & Priorities - S.PSS

Proceed by selecting the top-right arrow on the button of the next strategy and repeat the same steps for each remaining strategy until all strategies are completed.

ANALYSE EXISTING SYSTEM & SET PRIORITIES - S.PSS

Name, Company/Organisation
Name, Company/Organisation
Name, Company/Organisation

Analyse Existing System & Set Priorities - Home Page
Existing System Environmental Analysis & Priorities
New Board SYSTEM LIFE OPTIMIZATION
Concept Evaluation SYSTEM LIFE OPTIMIZATION
Sustainable Environmental Sustainability S.PSS

SYSTEM LIFE OPTIMIZATION

CHECKLIST

1. Are disposable systems used?
2. Are disposable products, packaging or support products used?
3. Do parts of the system tend to be technologically obsolete?
4. Do parts of the system tend to be culturally/aesthetically obsolete?
5. Do some parts of the system tend to wear out more easily (than others)?
6. Could the system stop working (or degrade critically) if external digital services or network connectivity that it relies on become unavailable (e.g., phase-out of cloud services, API/SDK licenses of digital services)?
7. Is there a mismatch between the digital and physical components' lifespans that shortens the system's durability (e.g., refreshes or feature drops / obsolescence)?
8. Others?

ENVIRONMENTAL SUSTAINABILITY

EVALUATION **PRIORITY** **HIGH** MEDIUM / LOW / NONE

2. High Quality food is disposed of...

SYSTEM LIFE OPTIMIZATION **REDUCE TRANSPORTATION** **MIN. RESOURCE CONSUMPTION** **WASTE MIN./ VALORIZATION** **CONSERVATION/ BIOCOMPATIBILITY** **TOXICITY REDUCTION**

Fig. 4.12 Shortcuts to each environmental strategies of the Existing System Environmental Analysis & Priorities - S.PSS

Continue by conducting the socio-ethical existing system analysis and priorities. Access the “Existing System Socio-Ethical Analysis & Priorities – S.PSS” board directly by selecting the corresponding button in the sidebar.

Fig. 4.13 Shortcut to Existing System Socio-Ethical Analysis & Priorities – S.PSS

“Existing System Socio-Ethical Analysis & Priorities – S.PSS” Guide

Follow the same step-by-step process used previously for the “Existing System Environmental Analysis & Priorities – S.PSS” and apply it to each of the socio-ethical strategies in the “Existing System Socio-Ethical Analysis & Priorities – S.PSS” board, repeating the process until all strategies have been completed.

Availability and Resources Required

The *Analyse Existing System & Set Priorities – S.PSS (Miro)* is an open-access tool freely available in the “Learning Resources – Tools” section of www.lenslab.polimi.it. A computer and a browser compatible with the Miro collaboration platform are required to access the tool. This tool requires at least:

- 45 minutes to write down qualitative assessment reports and set priorities for all of the environmental strategies;
- 45 minutes to write down qualitative assessment reports and set priorities for all of the socio-ethical strategies;

2) Sustainability Design Orienting Scenario (Miro)

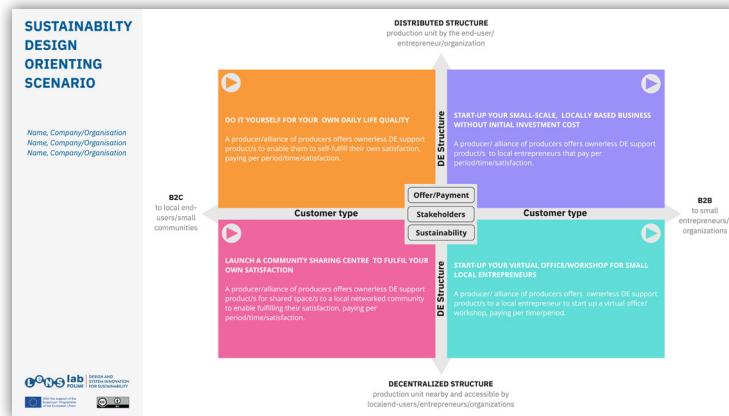


Fig. 4.14 Overview of the Sustainability Design Orienting Scenario

Aim

The objective of the *Sustainability Design Orienting Scenario (Miro)* 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.

Components

This tool consists of:

- 4 videos, one for each vision in the polarity diagram
- 3 sub-videos of offer / payment, system configuration, sustainability

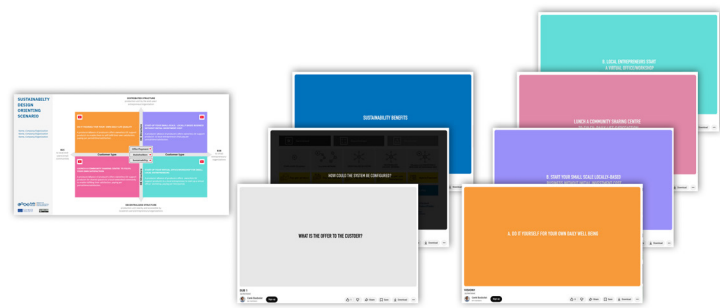


Fig. 4.15 Components of the Sustainability Design Orienting Scenario

Integration Into the MSDS Design Process

The *Sustainability Design Orienting Scenario (Miro)* is used within the Ideas Generation Oriented to Sustainability phase to create the analysis and set the priorities of the existing S.PSS.

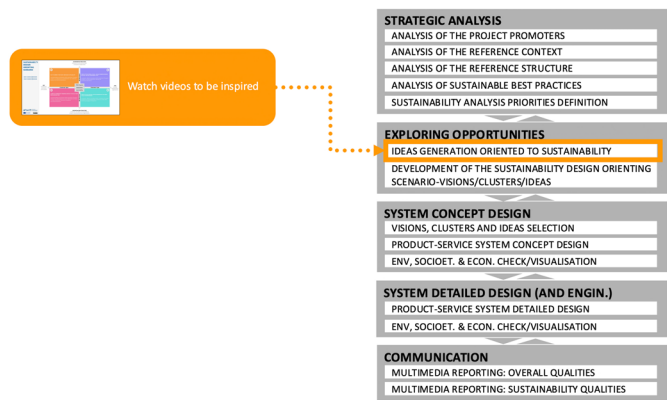


Fig. 4.16 Integrating Sustainability Design Orienting Scenario into MSDS design process

How to Use the *Sustainability Design Orienting Scenario (Miro)*

Before Starting

The first setup process is identical to the one described in 4.2.1. After installing Miro and finding LeNSlab Polimi in Miroverse, choose *Sustainability Design Orienting Scenario (Miro)*. As with all Miroverse templates, there are two ways to use this tool from the template page. One is to click “Use template”, which will create a new board with the tool in the logged-in account. Another one is to click the arrow on the right of “Use template,” then choose the existing board in the logged-in account; Miro will automatically duplicate the tool in the existing board.

This tool has a home board (Fig. 4.17) showing essential information, a video tutorial, and shortcuts for main section (Sustainability Design Orienting Scenario).

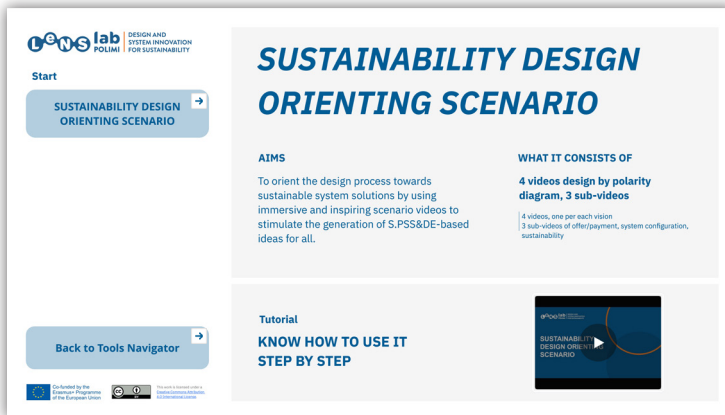


Fig. 4.17 The Home board of the Sustainability Design Orienting Scenario

“Sustainability Design Orienting Scenario” Guide

Click the arrow on the top-right corner of the "Sustainability Design Orienting Scenario" button on the "Home" board. Move there and write down the designer’s name and organization to begin using the board.

The main use of this tool is to watch a series of videos designed to support the understanding and development of more sustainable system solutions. Take a look at the four-quadrant diagram, where four different videos are available. Each video addresses a specific topic corresponding to its position within a quadrant. Access each video by selecting the play button icon within the corresponding quadrant. Apply the same method to view the videos in the other quadrants.

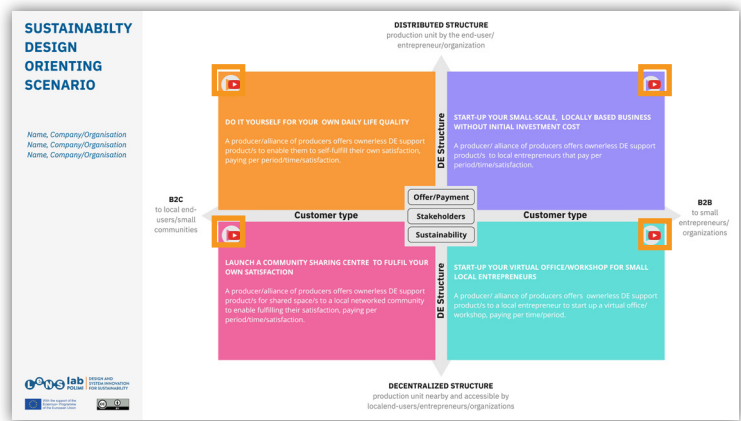


Fig. 4.18 Buttons to access videos of the Sustainability Design Orienting Scenario

In addition to the quadrant videos, access three sub-videos located in the rectangular area at the centre of the diagram. Each sub-video addresses a different topic. Open each sub-video by selecting the icon located in the top-right corner of the rectangle. Repeat this action for the remaining rectangles to view all available sub-videos.

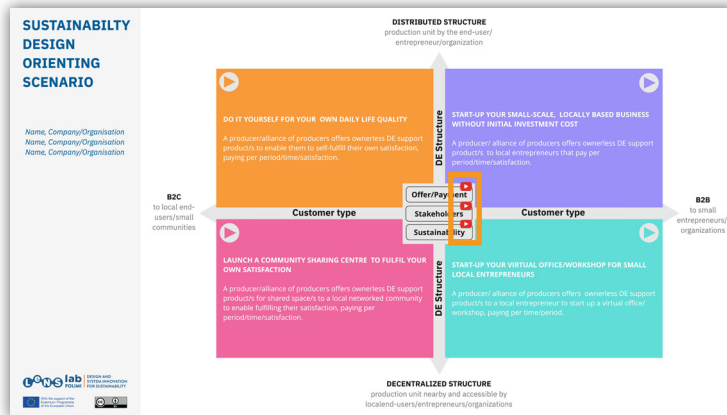


Fig. 4.19 Buttons to access sub-videos of the Sustainability Design Orienting Scenario

Availability and Resources Required

The *Sustainability Design Orienting Scenario (Miro)* is an open-access tool that can be used free from www.lenslab.polimi.it in the "Learning Resources - Tools" section. A computer and a browser that can use the Miro collaboration platform are needed to access the tool. This tool requires at least:

- 20 minutes to watch all of the videos located in the four-quadrant diagram;
- 6 minutes to watch all of the sub-videos located in the rectangular area at the centre of the diagram;

3) Idea Board – S.PSS (Miro)

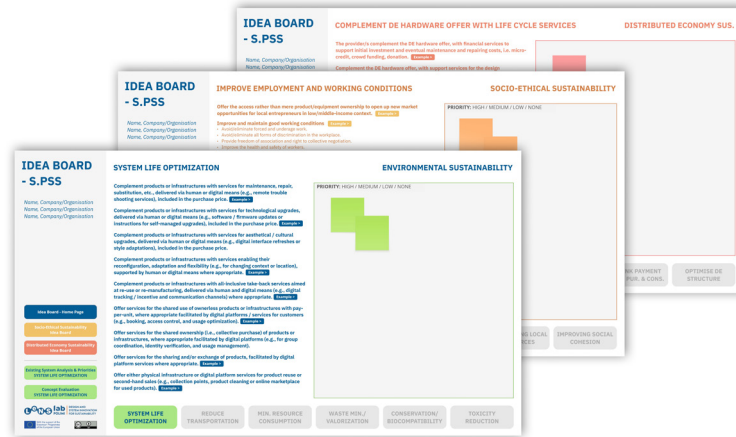


Fig. 4.20 Overview of the Idea Board – S.PSS

Aim

The objective of the *Idea Board - S.PSS (Miro)* is to orientate the development of sustainable product service system eventually apply to distributed economy towards environmentally, socio-ethically and economically win-win solution.

Components

The tool consists of:

3 sets of idea boards (with best practice examples):

- Environmental Sustainability Idea Board
- Socio-ethical Sustainability Idea Board
- Distributed Economies Sustainability Idea Board



Fig. 4.21 Components of the Idea Board – S.PSS

Integration Into the MSDS design process

The *Idea Board – S.PSS (Miro)* is used within the Ideas Generation Oriented to Sustainability phase to generate S.PSS ideas by brainstorming.

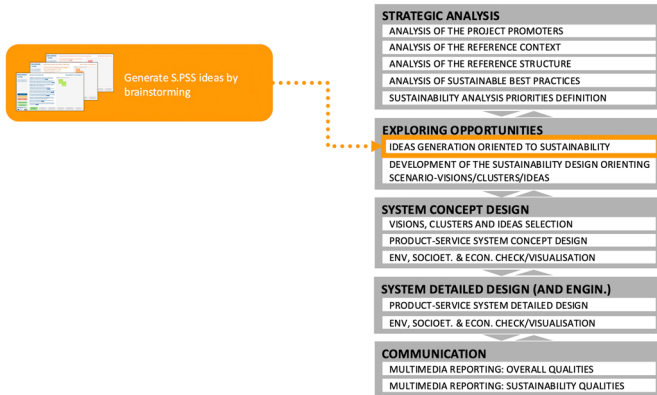


Fig. 4.22 Integrating Idea Board – S.PSS into MSDS design process

How to Use the *Idea Board - S.PSS (Miro)*

Before Starting

The first setup process is identical to the one described in 4.2.1. After installing Miro and finding LeNSlab Polimi in Miroverse, choose *Idea Board S.PSS (Miro)*. As with all Miroverse templates, there are two ways to use this tool from the template page. One is to click “Use template”, which will create a new board with the tool in the logged-in account. Another one is to click the arrow on the right of “Use template,” then choose the existing board in the logged-in account; Miro will automatically duplicate the tool in the existing board.

This tool has a home board (Fig. 19) showing key information, a video tutorial, and shortcuts for three main sections (Environmental Sustainability Idea Board - S.PSS / Socio-Ethical Sustainability Idea Board - S.PSS / Distributed



Fig. 4.23 The Home board of the Idea Board – S.PSS

Economies Sustainability Idea Board - S.PSS). The navigation bar on the left of each board helps users move quickly between the different boards in the tool. There are three main sections in this tool. Each section has six different strategies available across different boards.

“Environmental Sustainability Idea Board – S.PSS” Guide
Click the arrow on the top-right corner of the “Environmental Sustainability Idea Board – S.PSS” button on the “Home” board. Move there and write down the designer’s name and organization to begin using the board. Next,

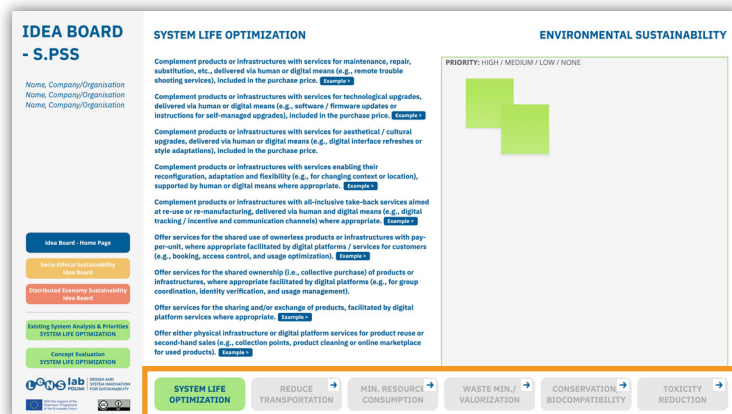


Fig. 4.24 Selection of strategies of the Environmental Sustainability Idea Board - S.PSS

select the environmental strategy to be addressed from the options available at the bottom of the board. Then, read all the guidelines provided as insights to support the generation of environmentally sustainable SPSS ideas. To further support idea generation, review the relevant case studies by selecting the example buttons and reading the provided material.

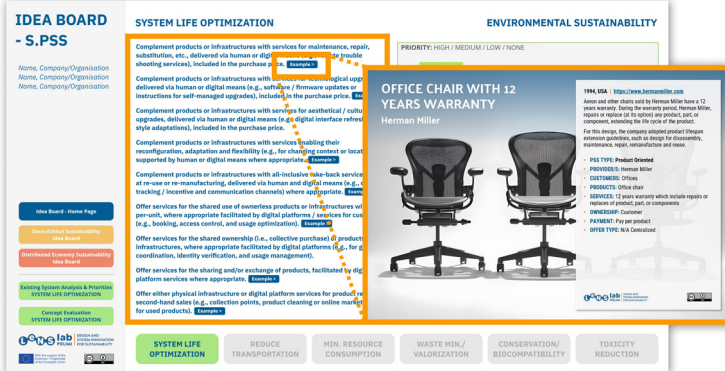


Fig. 4.25 Guidelines and examples of the Environmental Sustainability Idea Board - S.PSS

Start generating environmentally sustainable SPSS ideas using the post-its provided in the same colour. Duplicate the post-its as needed to record more ideas.

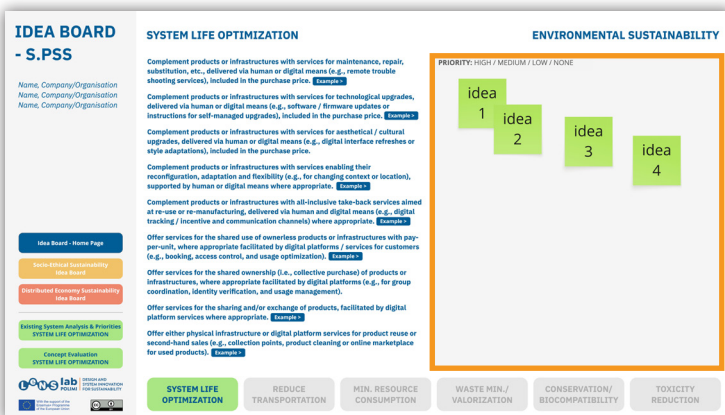


Fig. 4.26 Ideas generation of the Environmental Sustainability Idea Board - S.PSS

After completing the idea generation for the selected strategy, assign a priority level in line with the existing system analysis conducted earlier by highlighting the corresponding words in bold.

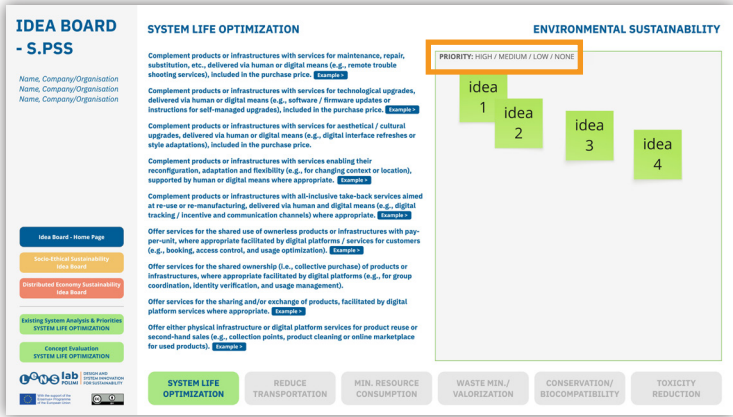


Fig. 4.27 Selection of priorities of the Environmental Sustainability Idea Board - S.PSS

Proceed to the next strategy by selecting the top-right arrow on the button of the next strategy and repeat the same steps for each remaining strategy until all strategies are completed.

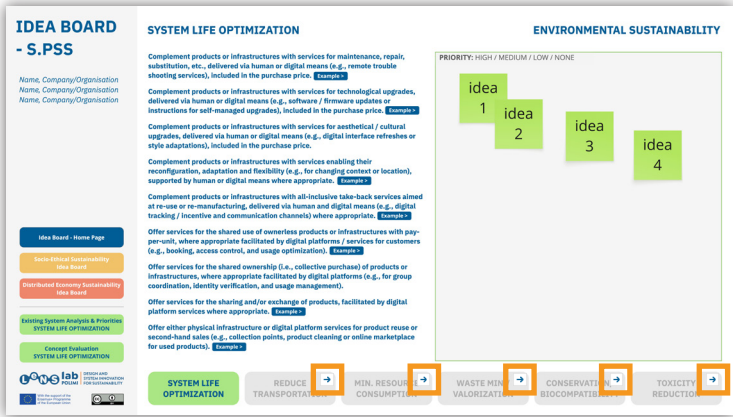


Fig. 4.28 Shortcuts to each environmental strategies of the Idea Board - S.PSS

Continue by conducting the socio-ethical existing system analysis and priorities. Access the “Socio-Ethical Sustainability Idea Board – S.PSS” directly by selecting the corresponding button in the sidebar.

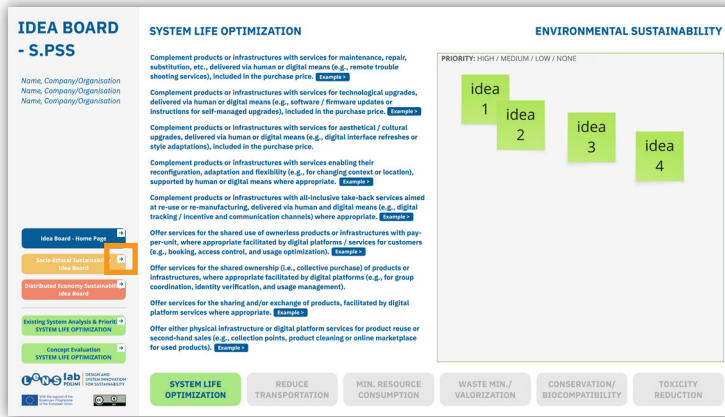


Fig. 4.29 Shortcut to Socio-Ethical Sustainability Idea Board - S.PSS

“Socio-Ethical Sustainability Idea Board – S.PSS” Guide

Follow the same step-by-step process used for the previous board and apply it to each of the socio-ethical strategies in the “Socio-Ethical Sustainability Idea Board – S.PSS”, until all strategies have been completed.

“Distributed Economy Sustainability Idea Board– S.PSS” Guide

Follow the same step-by-step process used for the previous board and apply it to each of the distributed economy strategies in the “Distributed Economy Sustainability Idea Board – S.PSS”, until all strategies have been completed.

Availability and Resources Required

The *Idea Board - S.PSS (Miro)* is an open-access tool that can be used free from www.lenslab.polimi.it in the “Learning Resources - Tools” section. A computer and a browser compatible with the Miro collaboration platform are required to access the tool. This tool requires at least:

- 60 minutes to generate S.PSS ideas for all of the environmental strategies;
- 60 minutes to generate S.PSS ideas for all of the socio-ethical strategies;
- 60 minutes to generate S.PSS ideas for all of the distributed economy strategies;

4. Innovation Diagram - S.PSS (Miro)

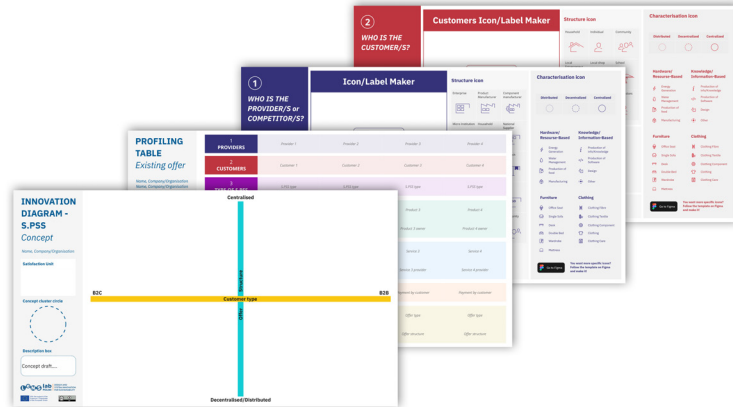


Fig. 4.30 Overview of the Innovation Diagram - S.PSS

Aim

The objective of the *Innovation Diagram - S.PSS (Miro)* is to: a) position and characterize existing offers; b) map competitors' strategic positioning; c) select promising system sustainability ideas and help to achieve a new concept drafting and profiling.

Components

This tool consists of:

- 3 Polarity diagrams
- Profiling tables
- Labels Maker & Repository
- Sample & video tutorial



Fig. 4.31 Components of the Innovation Diagram - S.PSS

Integration Into the MSDS Design Process

The *Innovation Diagram - S.PSS (Miro)* is used at various stages of the design process. In "Analysis of the project promoters and the reference context," the tool can be used to analyse the current offer and the related competitors' offers to orientate promising ideas. In "Visions, clusters and ideas selection and System concept development," the tool can be used to select, map, and cluster the most promising ideas and create the profile and S.PSS eventually applied to DE concept.

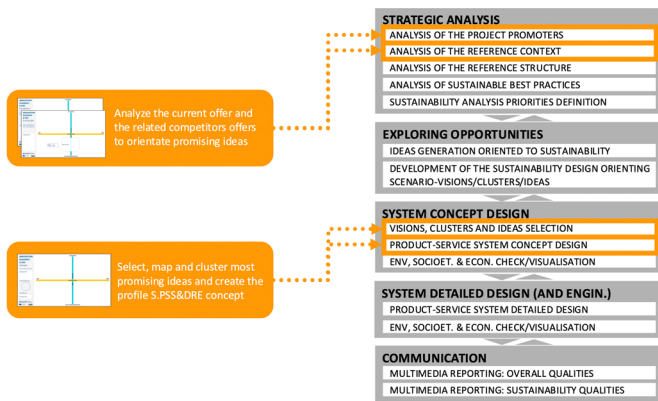


Fig. 4.32 Integrating Innovation Diagram - S.PSS into MSDS design process

How to Use the *Innovation Diagram- S.PSS (Miro)*

Before Starting

The first setup process is identical to the one described in 4.2.1. After installing Miro and finding LeNSlab Polimi in Miroverse, choose *Innovation Diagram - S.PSS (Miro)*. As with all Miroverse templates, there are two ways to use this tool from the template page. One is to click "Use template", which will create a new board with the tool in the logged-in account. Another one is to click the arrow on the right of "Use template," then choose the existing board in the

logged-in account; Miro will automatically duplicate the tool in the existing board.

This tool has a home board (Fig. 29) showing essential information, a video tutorial, and shortcuts for three main sections (Existing offer / Competitors / Concept). The navigation bar on the left of each board helps users move quickly between the different boards in the tool.

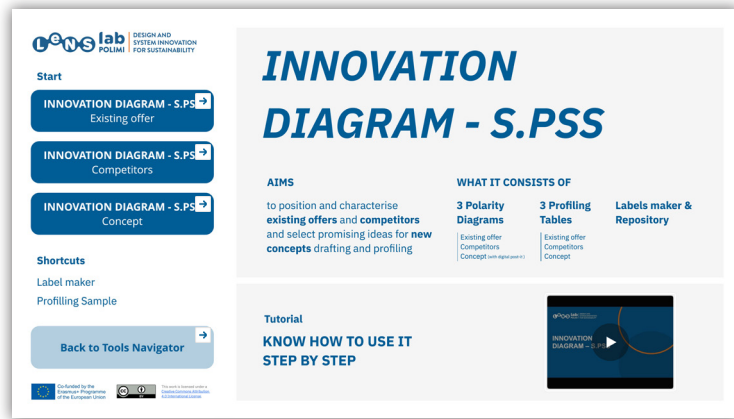


Fig. 4.33 The Home board of the Innovation Diagram - S.PSS

There are three main sections in this tool. Each has one Polarity diagram (Existing offer, Competitors, and Concept) and one / more profiling tables.

“Existing Offer” Guide

Click the arrow on the top-right corner of the “Existing offer” button on the “Home” board. Move to the “Existing offer” board to position an existing offer. Write down the designer’s name, organization, and the satisfaction unit. Then move to the label maker: 1) select and replace the default provider’s icon in the label template; 2) write the company / organization name in the text box of the label template. Successively, paste the label in the diagram and the profiling table on the right.

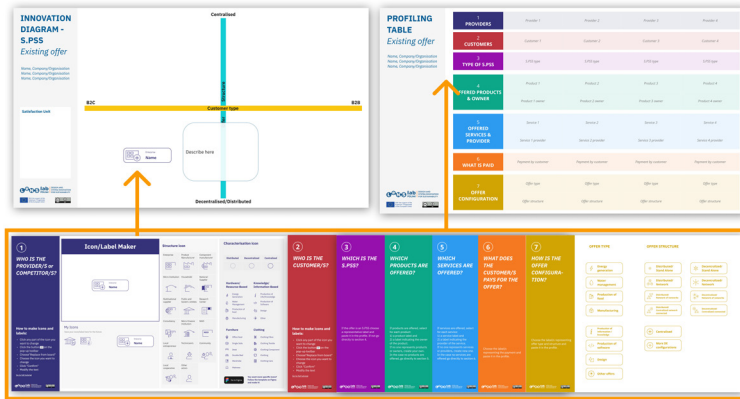


Fig. 4.34 The existing offer section of the Innovation Diagram - S.PSS

The provider's label is made of four parts: the structure icon, the characterization icon (DE types circle and offer type), descriptive text, and a frame. There are some tips for creating the icon: Double-click one of the three different parts of the default icon in the label template. Click “Replace - Replace from the board” on the pop-up toolbar, then select the icon from the Repository, click it, and finally, click “Confirm” to replace the default icon.



Fig. 4.35 Make the provider's icon

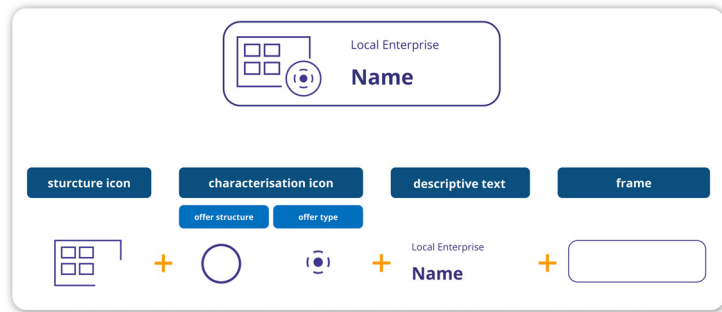


Fig. 4.36 Elements to characterize the existing offer in relation to the type of provider

The second step is to characterise the existing offer by specifying all the following in the profiling table:

- **Type of provider.** Select the structure icon/s of provider/s (company/organization). Choose one of the DE types in the characterization icons and find an offer type icon to substitute the default one (in the DE types circle). Write the company/organization name in the text box on the label and place it in the provider section.
- **Type of customer.** Select structure icon/s of customer/s (B2B – B2C). Choose one of the DE types in the characterization icons and find an offer type icon to substitute the default one (in the DE types circle). Write the customer/s name in the text box on the label and place it in the customer section.
- **Type of S.PSS.** 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.** Select the icon to represent the product that the company offers and paste it into the product section. Select who retains the product Ownership (provider or customer) and place the label below the product's ownership section.

- **Services/providers.** Select the icon to represent the service that the company offers and paste it into the service section. Select who Provides the service and place the label in the provider section below the services.
- **What is paid.** Select the icon describing what is paid by the customer/s and place the label in the payment section.
- **Offer configuration.** Select the DE type label of the offer and paste it into the DE type section. Select its structure icon label and place it in the section below the DE type label.

1 PROVIDERS	Provider 1	Provider 2	Provider 3	Provider 4
2 CUSTOMERS	Customer 1	Customer 2	Customer 3	Customer 4
3 TYPE OF S.PSS	S.PSS type	S.PSS type	S.PSS type	S.PSS type
4 OFFERED PRODUCTS & OWNER	Product 1 Product 1 owner	Product 2 Product 2 owner	Product 3 Product 3 owner	Product 4 Product 4 owner
5 OFFERED SERVICES & PROVIDER	Service 1 Service 1 provider	Service 2 Service 2 provider	Service 3 Service 3 provider	Service 4 Service 4 provider
6 WHAT IS PAID	Payment by customer	Payment by customer	Payment by customer	Payment by customer
7 OFFER CONFIGURATION	Offer type Offer structure	Offer type Offer structure	Offer type Offer structure	Offer type Offer structure

Fig. 4.37 Profiling table of the Innovation diagram - S.PSS Existing offer

The image (Fig. 4.36) exemplifies the process of realizing providers' icons and labels. With the same logic, the process can be applied to customers, the type of S.PSS, offered products and owners, offered service and providers, and payment and offer configuration. If the icons need to be more specific, there is a Figma template (link is on the bottom right corner of the label maker) to help draw new icons.

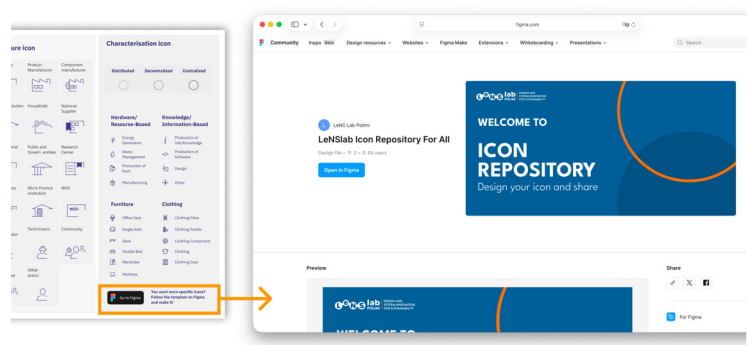


Fig. 4.38 Figma template for drawing new icons

“Competitor” and “Concept” Guide

The exact process could be used to characterize the competitors’ existing offer by moving to the “Competitors” board.

The *Innovation Diagram - S.PSS* is also meant to be combined with other tools. Indeed, in the "Concept" section, the tool can be used to select and position promising ideas developed with another tool, namely the Idea Board (following the colour code in the Idea Board).

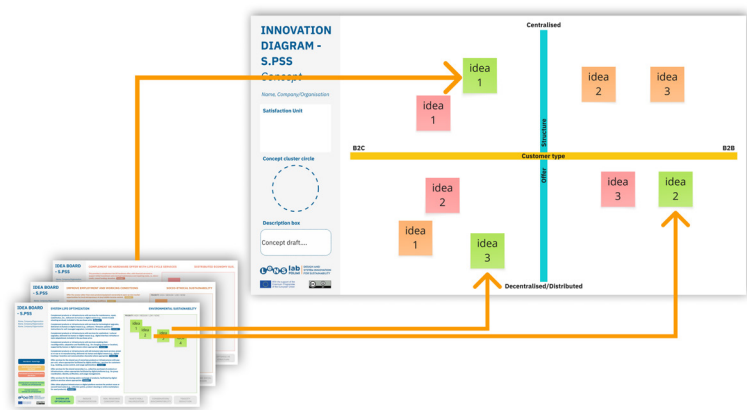


Fig. 4.39 Concept slide of Innovation Diagram - S.PSS with the Idea Board

After moving the ideas to the "Concept" board (Fig. 11): Generate some new ideas, spotting the areas that are left empty (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).

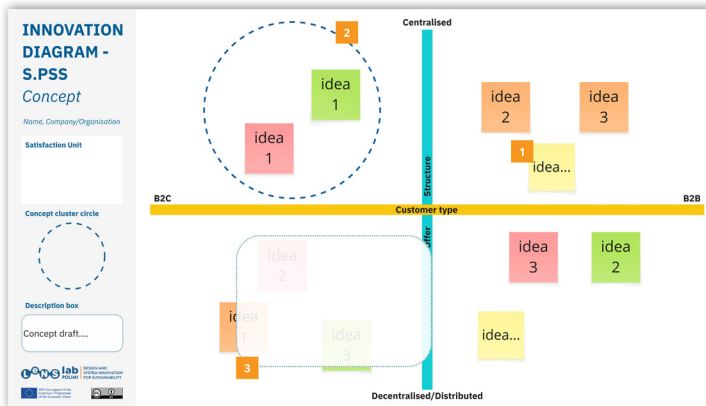


Fig. 4.40 Idea generation, idea clustering, and system concept drafting

Finally, the S.PSS eventually applied to DE draft concept is profiled by copying and pasting labels of the emerging S.PSS (&DE) concept.

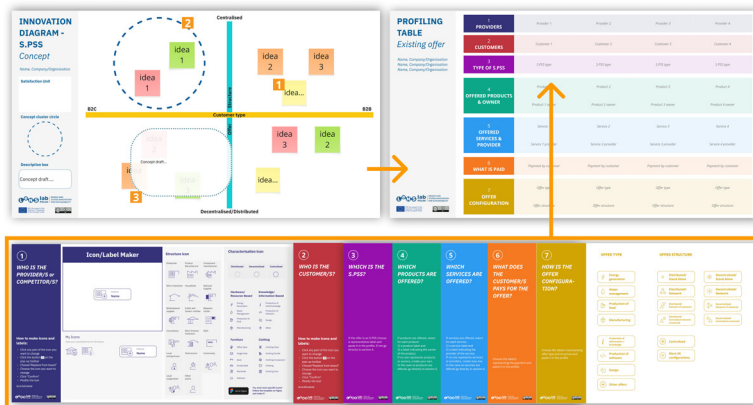


Fig. 4.41 Profiling S.PSS eventually applied to DE draft concept

Availability and Resources Required

The *Innovation Diagram - S.PSS (Miro)* is an open-access tool freely available in the “Learning Resources – Tools” section of www.lenslab.polimi.it. A computer and a browser compatible with the Miro collaboration platform are required to access the tool. This tool requires at least:

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

Similar Tools

This chapter presents the tool *Innovation Diagram - S.PSS (Miro)*. It is an updated version of the PPT-based Innovation Diagram for S.PSS. Another type-specific tool, the Innovation Diagram for S.PSS & DG (Distributed energy Generation) has been developed to support the specific S.PSS & DG 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 draft and profiling. The Innovation Diagram for S.PSS & DG can be found in the book “Designing Sustainable Energy for All” (Vezzoli et al., 2018), chapter 7.2.8.

5) Concept Description Form - S.PSS (Miro)

Aim

The objective of the Concept Description Form - S.PSS is to finalize the description and characterization of a new concept of S.PSS eventually applied to DE.

Concept Description Form - S.PSS

Name, Company/Organisation
Name, Company/Organisation
Name, Company/Organisation

CONCEPT TITLE

SATISFACTION UNIT

CONCEPT DESCRIPTION

PROVIDERS

CUSTOMERS

TYPE OF S.PSS

OFFERED PRODUCTS & OWNER

OFFERED SERVICES & PROVIDER

WHAT IS PAID

OFFER CONFIGURATION

GigaLab INNOVATION AND SUSTAINABILITY

European Union

Fig. 4.42 Overview of the Concept Description Form - S.PSS

Components

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 and owner, Offered Services and provider, what is paid, Offer configuration.)
- Sample and writing guide



Fig. 4.43 Components of the Concept Description Form- S.PSS

Integration Into the MSDS Design Process

The Concept Description Form - S.PSS is used within the Product Service System concept design phase to describe and profile the designed S.PSS eventually applied to DE concept.

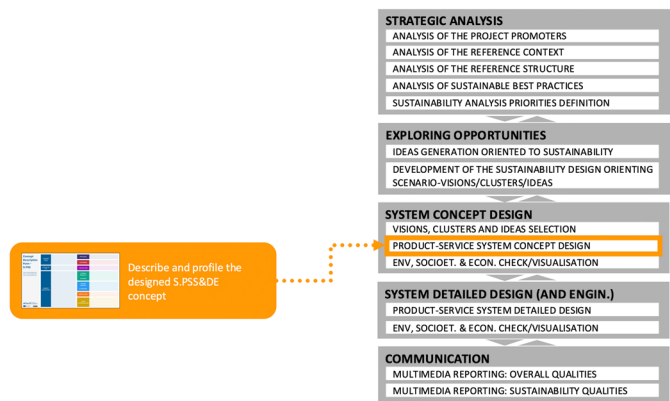


Fig. 4.44 Integrating Concept Description Form - S.PSS into the MSDS method

How to Use the *Concept Description Form- S.PSS (Miro)*

Before Starting

The first setup process is identical to the one described in 4.2.1. After installing Miro and finding LeNSlab Polimi in Miroverse, choose *Concept Description Form - S.PSS*. As with all Miroverse templates, there are two ways to use this tool from the template page. One is to click “Use template”, which will create a new board with the tool in the logged-in account. Another one is to click the arrow on the right of “Use template,” then choose the existing board in the

logged-in account; Miro will automatically duplicate the tool in the existing board.

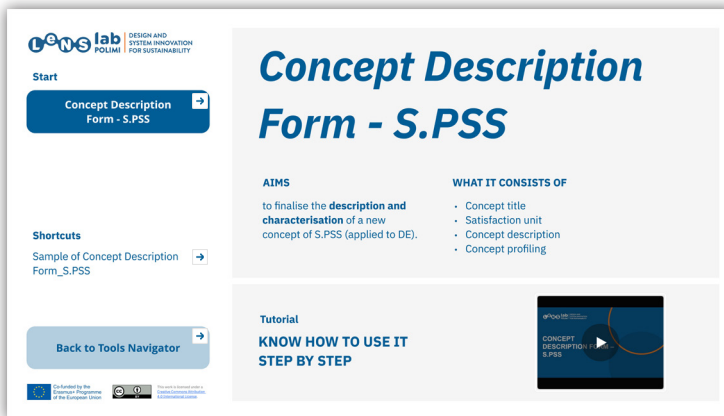


Fig. 4.45 The Home board of the Concept Description Form - S.PSS

This tool has a home board (Fig. 4.45) showing essential information, a video tutorial, and shortcuts for different parts of this tool. The navigation bar on the left of each board helps users move quickly between the different boards in the tool.

“Description Form” Guide

Click the arrow on the top-right corner of the **Concept Description Form – S.PSS** button on the home board. Move to the tool (Fig. 42). The title (1) and the description (3) of the S.PSS concept must be written in the respective boxes. Indicate the unit of satisfaction of the concept (2) and finally characterize it with information in all fields (4). Texts or labels are both acceptable in the profiling part of the form.

Concept Description Form - S.PSS

1 **CONCEPT TITLE**

2 **SATISFACTION UNIT**

3 **CONCEPT DESCRIPTION**

4 **PROVIDERS**

CUSTOMERS

TYPE OF S.PSS

OFFERED PRODUCTS & OWNER

OFFERED SERVICES & PROVIDER

WHAT IS PAID

OFFER CONFIGURATION

Name, Company/Organisation
Name, Company/Organisation
Name, Company/Organisation

lenslab
lenslab
lenslab

Fig. 4.46 The order to fill all components of the Concept Description Form - S.PSS

Availability and Resources Required

The *Concept Description Form - S.PSS (Miro)* is an open-access tool freely available in the “Learning Resources – Tools” section of www.lenslab.polimi.it. A computer and a browser compatible with the Miro collaboration platform are required to access the tool. This tool requires at least 15 to 30 minutes to be completed.

6) System Map - S.PSS (Miro)

Aim

The purpose of the System Map - S.PSS (Miro) is to support designing (co-designing) and visualizing stakeholders' configuration of the Sustainable Product Service Systems eventually applied to DE, indicating the actors involved and their interactions in the system and providing additional support to its users in defining DE configuration.

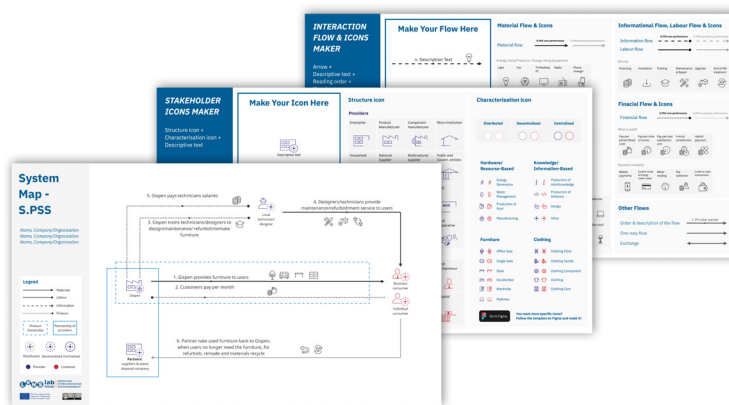


Fig. 4.47 Overview of the System Map - S.PSS

Components

The *System Map - S.PSS (Miro)* is a graphical representation of:

- The stakeholders involved
- Flows/interactions between them: physical, financial, informational, or labour performance

In the tool, it contains:

- A system map template
- Stakeholder icon maker and icon repository
- Flow maker and flow repository
- System map sample and tutorial



Fig. 4.48 Components of the System Map - S.PSS

Integration Into the MSDS Design Process

The System Map - S.PSS (Miro) is used at various stages of the design process:

- 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.

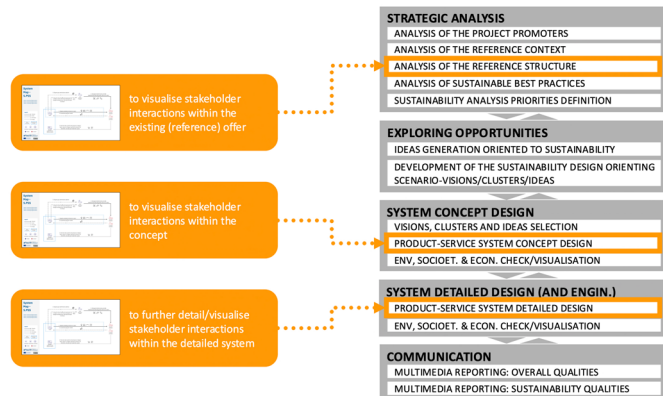


Fig. 4.49 System Map - integration into the MSDS design process

How to Use the *System Map- S.PSS (Miro)*

Before Starting

The first setup process is identical to the one described in 4.2.1. After installing Miro and finding LeNSlab Polimi in

Miroverse, choose *System Map - S.PSS (Miro)*. As with all Miroverse templates, there are two ways to use this tool from the template page. One is to click “Use template”, which will create a new board with the tool in the logged-in account. Another one is to click the arrow on the right of “Use template,” then choose the existing board in the logged-in account; Miro will automatically duplicate the tool in the existing board.

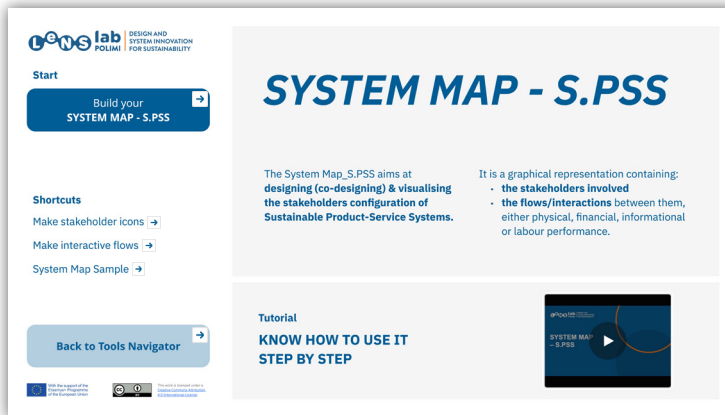


Fig. 4.50 The Home board of the System Map - S.PSS

This tool has a home board (Fig. 4.50) showing essential information, a video tutorial, and shortcuts for different parts of this tool. The navigation bar on the left of each board helps users move quickly between the different boards in the tool.

“System Map” Guide

Click the arrow on the top-right corner of the “Build your System Map” button on the home board. Move to the template. The *System Map - S.PSS (Miro)* enables comprehensive visualization of the system structure. The first step is to set boundaries (Fig. 4.51), including offer boundary (1) where the main stakeholders must be positioned, and set a system boundary for the secondary ones (2). The template has an adjustable grey rectangle on the right part to represent the offer boundary. The border of the white background represents the secondary boundary.



Fig. 4.51 Setting boundaries and stakeholders (System Map - S.PSS)

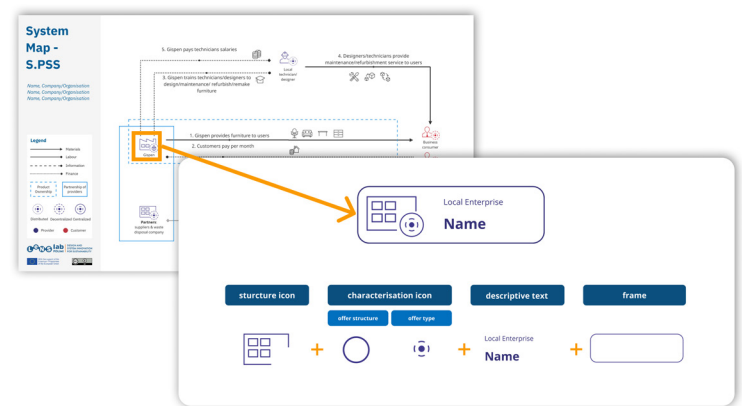


Fig. 4.52 Characterizing stakeholders (System Map - S.PSS)

Icons are used here to represent different stakeholders (Fig. 4.52). There are four parts to the icon: structure icon, characterization icon, description text, and an invisible frame. Structure icons must be combined with characterization icons and descriptive text to characterize the stakeholder. Another element that distinguishes stakeholders is the colour (Fig. 4.53): dark violet is used for providers , while magenta is used for customers.

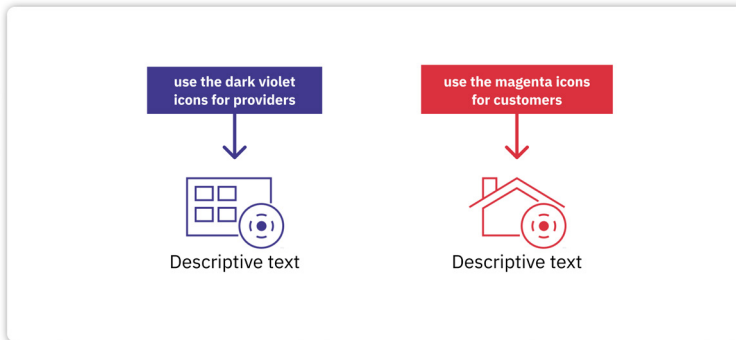


Fig. 4.53 Distinguishing stakeholders by colours (System Map - S.PSS)

All the icons can be made in the "Icon maker" board (Fig. 4.54) of the tool, from which they can be designed and drag-dropped into the system map board.

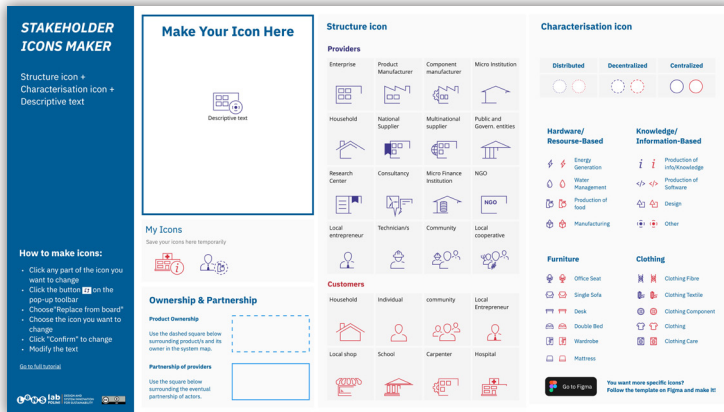


Fig. 4.54 Icon Maker of the System Map - S.PSS

"Icon Maker" Guide

In the home board, click the **"Make stakeholder icons"** button in the navigator and move to the Icon Maker board (Fig. 4.55). The maker has a default stakeholder icon consisting of a structure icon, a characterization icon, and descriptive text (1). A pop-up toolbar (2) will appear after double-clicking the structure icon in the default stakeholder icon. Click "replace" and "replace from the board" on the bar (2), then choose the icon in the structure icon

repository (3) to replace the default one. For example, select the research centre icon as the structure icon. Click it and confirm. It will replace the default one automatically. Then, modify the characterization icon (4) using the same rules. Finally, double-click the text part in the stakeholder icon to change the description text. After adjusting, please select the whole icon, copy it, and then click the system map button in the navigator to back, paste, and position it. Usually, position the provider/s (in dark violet) on the left part of the system map and the customer/s (in magenta) on the right. If the icons need to be more specific, there is a Figma template (link is on the bottom right corner of the label maker) to help draw new icons.

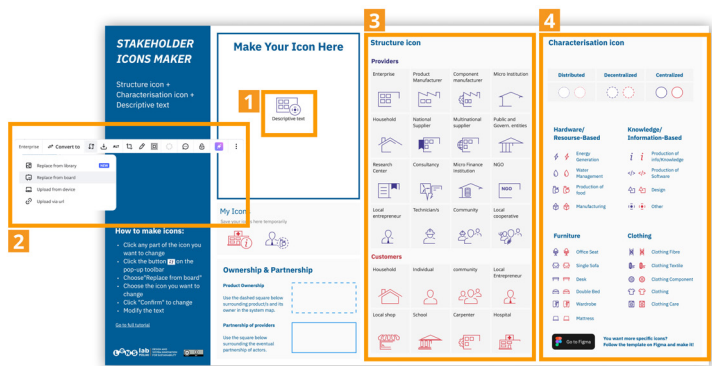


Fig. 4.55 Make the provider's icon

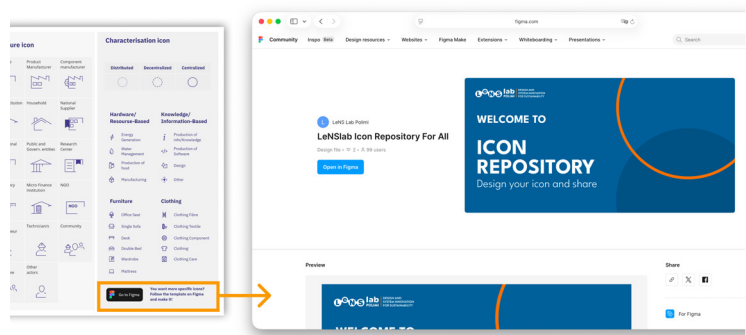


Fig. 4.56 Figma template for drawing new icons

Later, define interaction flows using arrows and descriptions (Fig. 4.57). Interaction flows can be material flow, information flow, financial flow, and labour flow (Fig. 4.58). Remember that the reading order is important (Fig. 4.59); thus, note the numbering of the interaction flows.

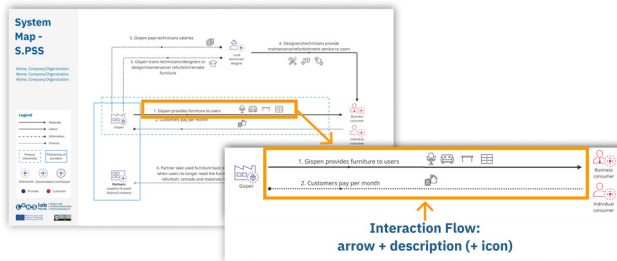


Fig. 4.57 Defining interaction flows of the System Map - S.PSS

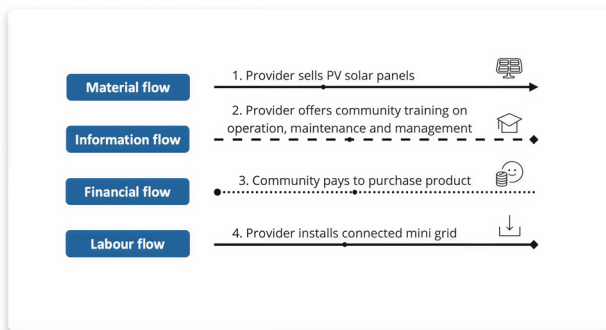


Fig. 4.58 Types of interaction flows (System Map - S.PSS)

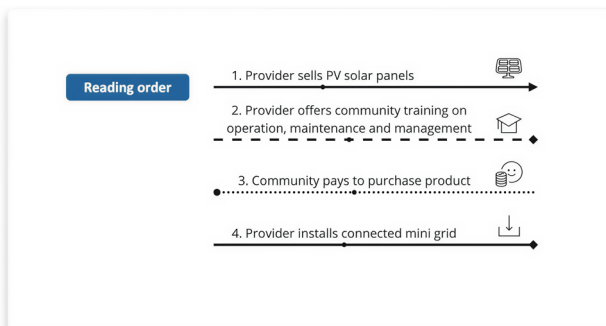


Fig. 4.59 Numbering of interaction flows (System Map - S.PSS)

There are two ways to create interaction flows: 1) move to the "Flow maker" board of the tool, drag and drop the modified flows into the system map template, and 2) create flows directly in the system map template.

"Flow Maker" Guide

In the home board, click the **"Make interactive flows"** button in the navigator and move to the Flow Maker board (Fig. 4.60). In the maker (Fig. 4.61), there is a default flow (1) that consists of an arrow, descriptive text, and an icon (to show what the stakeholder offers in the system). A pop-up toolbar (2) will show up after double-clicking the arrow in the default flow. Click the **"Arrow"** shown on the toolbar, then choose a different end style, like dot end, triangle end, and so on... the line style of the arrow can also be modified by clicking the **"line style"** on the pop-up toolbar. Click **"colour"** on the bar to alter the arrow's colour. Mix with three line styles, three end styles, and colours; 8 different arrows can be used in the system map. All style references can be found in the style guide on the right of the Flow maker board. After modifying the arrow, double-click the text on the arrow to write down what the providers offer in the system by text. Then, replace the default icon above the arrow with the same rules for creating the stakeholder's icon. After making the flow, copy and paste all the elements to the system map and connect stakeholders through it.

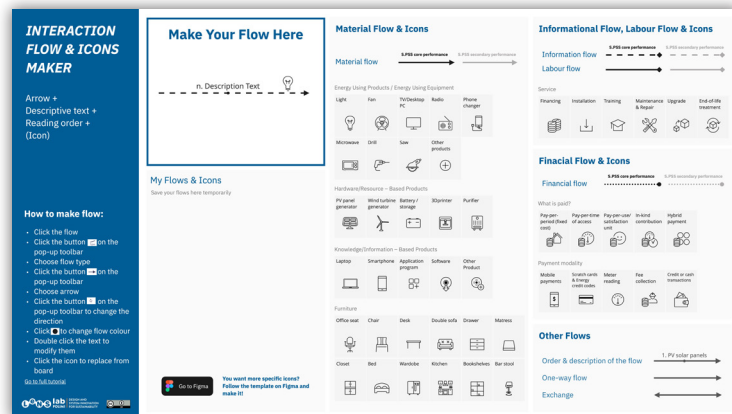


Fig. 4.60 Flow maker of System Map - S.PSS

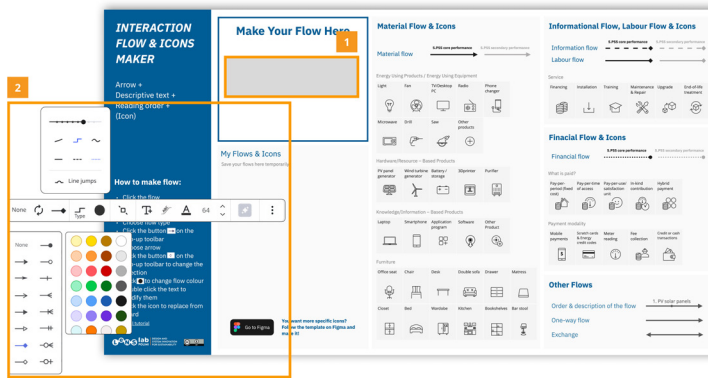


Fig. 4.61 Make the Flow in the Flow Maker

How to Create Flows Directly in the System Map Template

There is an invisible frame behind the stakeholder icon. Double-click it, and there will be four dots showing up around. Please choose any of them and drag them to another stakeholder. The flow will be built automatically. The pop-up bar shown above the arrow can help with restyling by using functions like "ends style," "line style," "colour," "text," and so on. The legend is on the left of the whole system map; remember to follow the style guide. Copy and paste one icon from the Flow maker, then use the same process of "replacing" to change the icon as before.

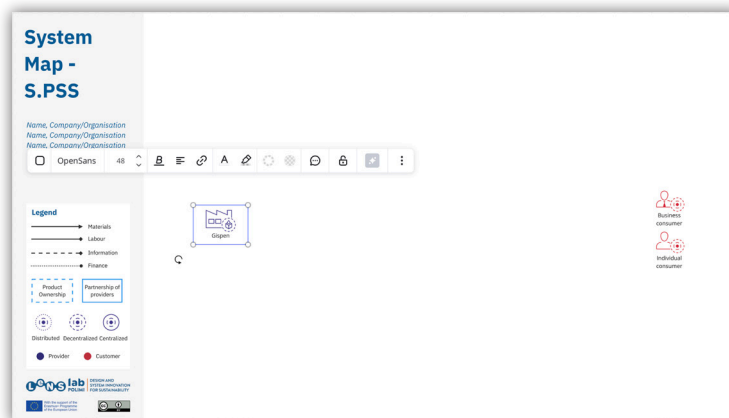


Fig. 4.62 Make the Flow directly in the System Map - S.PSS template

Finally, dashed squares (Fig. 4.63) are used to indicate ownership of a system of a product, and squares (Fig. 4.64) around actors are used to indicate partnership. Both dashed squares and squares are similarly available on the "Icon maker" board.

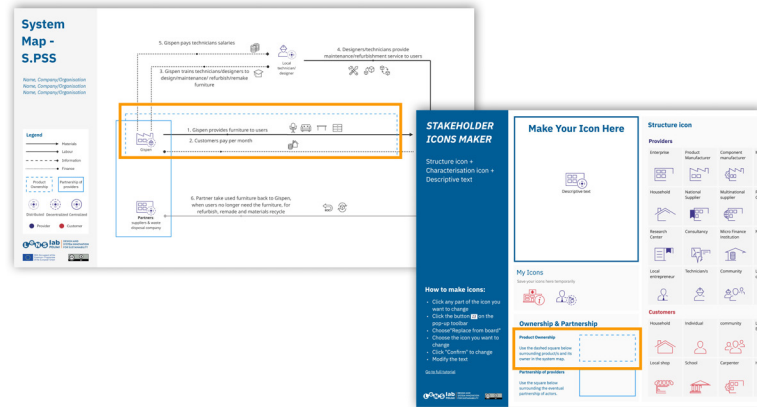


Fig. 4.63 Dashed squares indicating ownership (System Map - S.PSS)

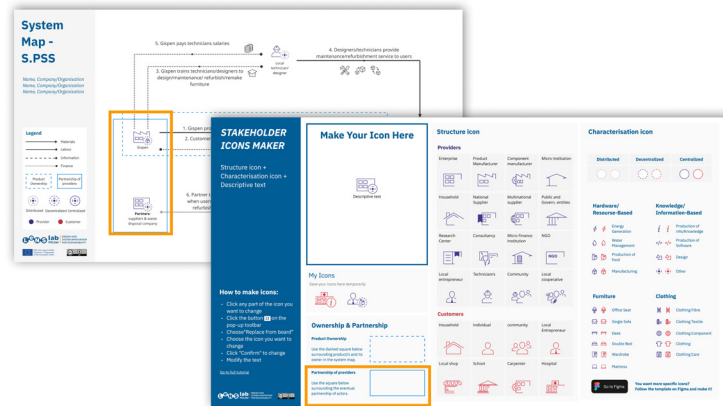


Fig. 4.64 Squares indicating partnership (System Map - S.PSS)

Availability and Resources Required

The *System Map - S.PSS* can be drawn up on paper without using any software. It is, however, advisable to

use the Miro collaboration platform, or similar software, to support collaborative work and make revisions easier. The *System Map - S.PSS (Miro)*, complete with labels and icon repositories, is an open-access tool freely available in the “Learning Resources – Tools” section of www.lenslab.polimi.it. The tool is based on a layout and a set of standardised icons for use with the Miro collaboration platform. A Figma template is also provided, allowing users to customise the icons and create new ones.

The tool was developed for use by any design team member, with no special graphical skills required. The time required to set up a *System Map - S.PSS* depends on the level of detail along the design process; nevertheless, it could range from approximately 60-90 minutes.

Similar Tools

This chapter presents the tool *System Map - S.PSS (Miro)*. It is an updated version of the PPT-based System Map for S.PSS & DE. Another type-specific tool is the System Map for S.PSS & DG (Distributed Energy Generation), which has been developed to support visualization and configuration of the DG-specific system structure while co-designing. This is done by indicating the actors involved and their interactions in the system, providing additional support to its users who define DG configuration. System Map for S.PSS & DG can be found in the book “Designing Sustainable Energy for All” (Vezzoli et al., 2018), chapter 7.2.7.

7) Interaction Table (Miro)

Aim

The objective of the *Interaction Table (Miro)* is to design (co-design) and visualize 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).



Fig. 4.65 Overview of the Interaction Table

Components

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

- The sequence of activity cards, with images and 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 and a narrative of the scenario;
- The product and services delivered in each action (highlighting ownership, life cycle responsibilities, and provider).

In addition to a sample and tutorial, the tool also includes:

- An interaction table template
- A card maker and card repository
- Label maker



Fig. 4.66 Components of the Interaction Table

Integration Into the MSDS Design Process

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

- Within the strategic analysis, examining the reference structure can help evaluate the existing system by describing its 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 further development (in detail) of all the system interactions.

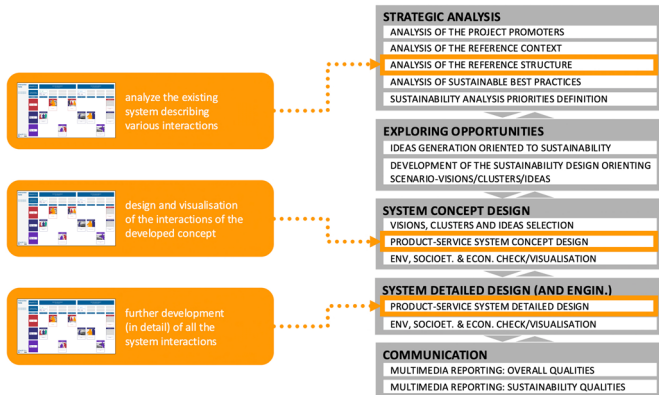


Fig. 4.67 Integration of the Interaction Table into the MSDS design process

How to Use the *Interaction Table* (Miro)

Before Starting

The first setup process is identical to the one described in 4.2.1. After installing Miro and finding LeNSlab Polimi in Miroverse, choose ***Interaction Table* (Miro)**. As with all Miroverse templates, there are two ways to use this tool from the template page. One is to click “Use template”, which will create a new board with the tool in the logged-in account. Another one is to click the arrow on the right of “Use template,” then choose the existing board in the logged-in account; Miro will automatically duplicate



Fig. 4.68 The Home board of the Interaction Table

the tool in the existing board. This tool has a home board (Fig. 4.68) showing essential information, a video tutorial, and shortcuts for different parts of this tool. The navigation bar on the left of each board helps users move quickly between the different boards in the tool.

“Interaction Table” Guide

Click the arrow on the top-right corner of the “***Interaction Table***” button on the home page. Move to the template. The Interaction Table (Miro) is composed by:

- **The first row:** represents the process phases;
- **The second row:** hosts both products and services

needed to carry out each single action, with the indication of product ownership / life cycle responsibility and service provider;

- **Other rows:** represent each actor involved in their activities in the system;

Different colour codes are used to identify specific stakeholders.

- **The first column:** represents the actors of the system divided as customer /s (red) and provider /s (blue and violet shades);
- **Other columns/row:** presents the sequence of all activities happening in the system.



Fig. 4.69 Composition of the Interaction Table (1)

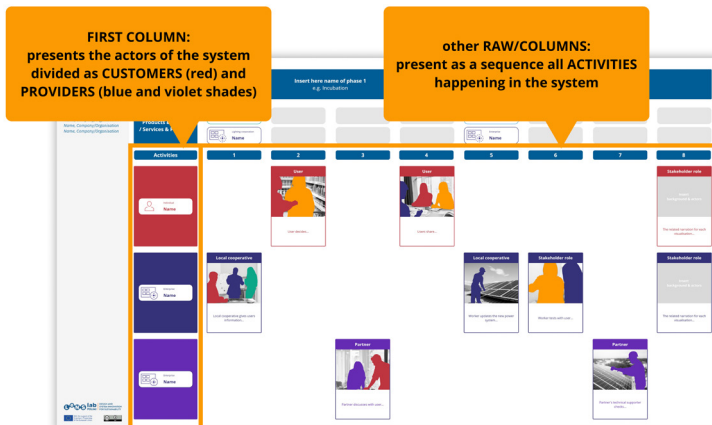


Fig. 4.70 Composition of the Interaction Table (2)

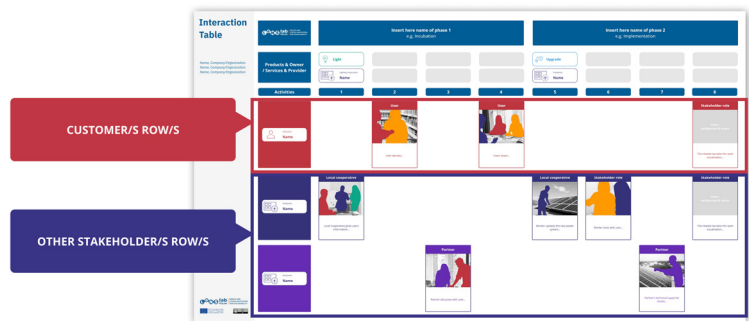


Fig. 4.71 Composition of the Interaction Table (3)

First, insert the stakeholders' labels within the first column. Labels can be taken from the other tools (e.g., Innovation diagram - S.PSS). Labels can be dragged and dropped if stakeholders have already been defined within those tools. Also, labels can be made here using this tool in the label maker.

“Label Maker” Guide

For the provider/s:

- Select the structure icon/s of provider/s (company/ organization).
- Choose one of the DE types in the characterization icons and find an offer type icon to substitute the default one (in the DE types circle).
- Write the company/organization name in the text box on the label and place it in the provider section.

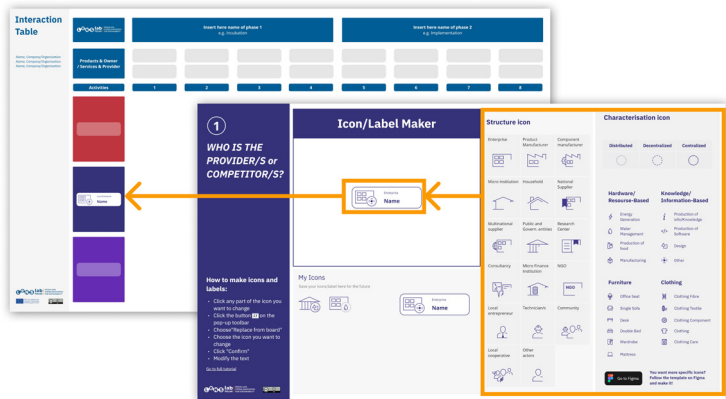


Fig. 4.72 How to make the provider/s' label

For the customer/s:

- Select structure icon/s of customer /s (B2B – B2C).
- Choose one of the DE types in the characterization icons and find an offer type icon to substitute the default one (in the DE types circle).
- Write the customer /s name in the text box on the label and place it in the customer section.

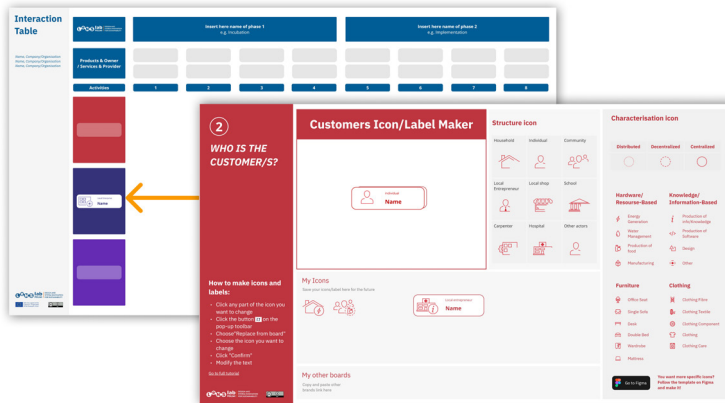


Fig. 4.73 How to make the customer/s' label

Continue filling in the table with the definition of the system activities. To make all the interactions clear, users can create Activity Cards. There are three main contents in one activity card: the stakeholder's role in the system, an image to show the key elements of this activity, and a narrative text to describe this activity in detail. All three contents were framed in a rectangle whose border's colour follows the colour code of the stakeholder.



Fig. 4.74 The Activity Card

"Card Maker" Guide

Double-click text boxes to modify them. For the image, follow the same process of replacing, but this time choose "Replace - Replace from device." There are two parts to an image. One is stakeholders, represented by their colours; another is the background, representing the context of each action (possibly black and white). Images can be made in many different ways.

There are 3 to introduce:

- Use the "Image Library" provided by LeNSlab Polimi to get all the elements you need to make the image
- Use the Figma template to make an image
- Use image editing software like Photoshop or even artificial intelligence to edit or generate images.

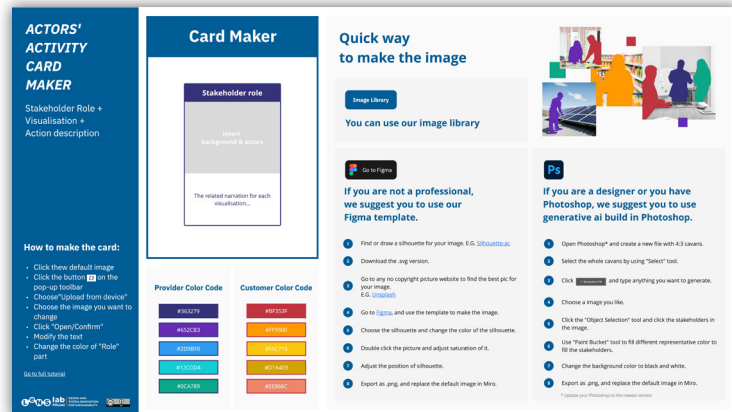


Fig. 4.75 The Card Maker

Tips on Using Figma Image Template

- Download the needed silhouettes in .svg and put them into Figma to modify the colour
- Get the background picture and adjust the saturation in Figma
- Move these two kinds of elements into the image template in Figma and export the whole frame as .png
- Replace the default image in Miro with the new image.

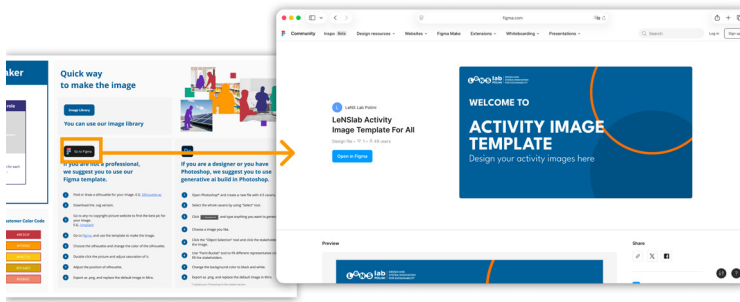


Fig. 4.76 Using the Figma template to make the image

Tips on Using Photoshop and Generative AI in Photoshop:

- Create a new 4:3 canvas and select the whole canvas;
- Click "Generative Fill" and type a description of the action;
- Choose a proper image and select the stakeholders by using the "Subject Selection" tool;
- Fill the stakeholders with the colour code;
- Change the background image to black and white;
- Export as .png and replace the default image in Miro.

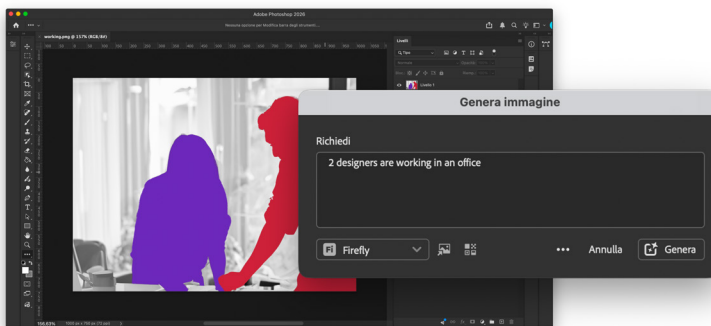


Fig. 4.77 Using Photoshop Generative AI to make the image

Finally, other element labels are placed on the second row to represent the product, its owner, service, and provider. Labels can be taken from the Interaction Table or other tools, such as the Innovation Diagram SPSS&DE, if they have already been created.

Availability and Resources Required

The *Interaction Table (Miro)*, complete with the “Image library” and Figma image template, is an open-access tool freely available in the “Learning Resources – Tools” section of www.lenslab.polimi.it. A computer and a browser compatible with the Miro collaboration platform are required to access the toolkit; access to Figma and/or Photoshop is also recommended. This tool requires 60 to 120 minutes to complete.

Similar Tools

This chapter presents the tool *Interaction Table (Miro)*. It is an updated version of the System Map for Interaction Table (PPT). Other similar tools are:

- The Customer Journey Map
- The Blueprint.

8) Interaction Storyboard (Miro)

Aim

The objective of the Interaction Storyboard (Miro) is to show a fluent narration of the functioning system to the customer /s or the other actors involved in the project during the design process.

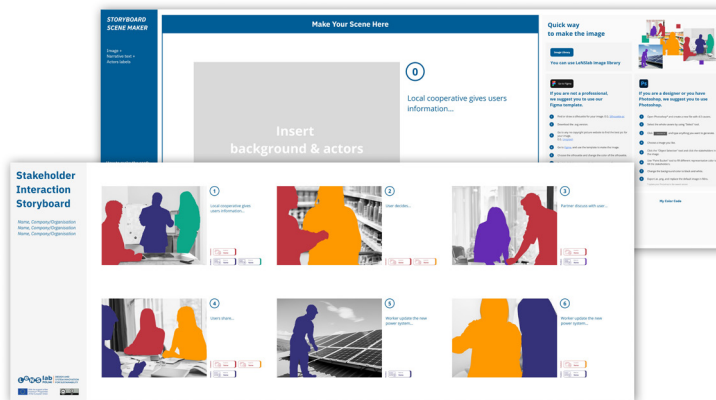


Fig. 4.78 Overview of the Interaction Storyboard

Components

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

There are also:

- Storyboard Templates
- Scene maker
- Sample and tutorial
- The template is made of a sequence of scenes and can be present in Miro



Fig. 4.79 Components of the Interaction Storyboard

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.

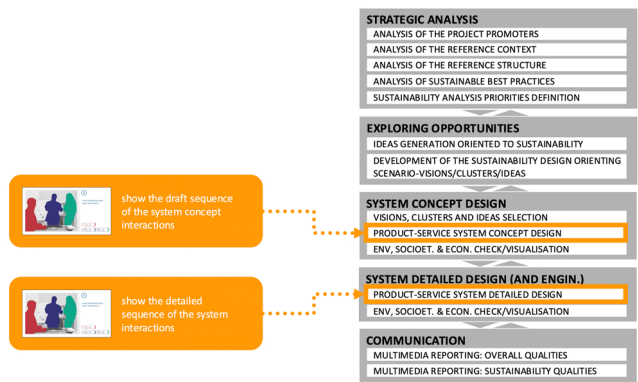


Fig. 4.80 Integration of the Stakeholders Interaction Storyboard within the MSDS Method

How to Use the *Interaction Storyboard (Miro)*

Before Starting

The first setup process is identical to the one described in 4.2.1. After installing Miro and finding LeNSlab Polimi in Miroverse, choose *Interaction Storyboard*. There are two ways to use this tool from the template page. One is to click “Use Template,” Miro will create a new board with the tool in the logged-in account. Another one is to click the arrow on the right of “Use Template,” then choose the existing board in the logged-in account, and Miro will duplicate the tool in the existing board automatically.

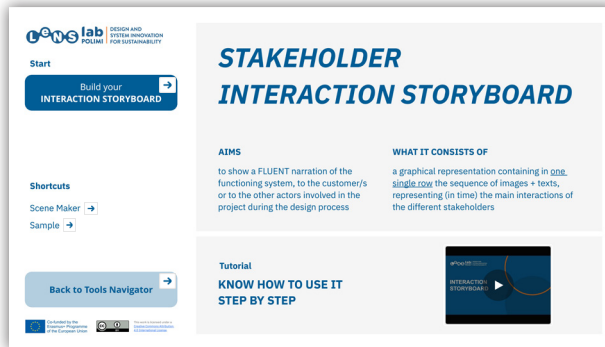


Fig. 4.81 The Home board of the Interaction Storyboard

This tool has a home page showing essential information, a video tutorial, and shortcuts for different parts of this tool. The navigation bar on the left of each board helps users move quickly between the different boards in the tool.

“Interaction Storyboard” Guide

Click the arrow on the top-right corner of the “Build your Interaction Storyboard” button on the home page. Move to the template.

The tool is composed of a series of scenes of the action with background and coloured actors’ silhouettes (stakeholders), where the number of the action is also reported in the narration sequence. On the right of the main scene is a narrative description of the action and a legend in the bottom-right corner with labels that identify the actors in the scene (customers, providers, or others).

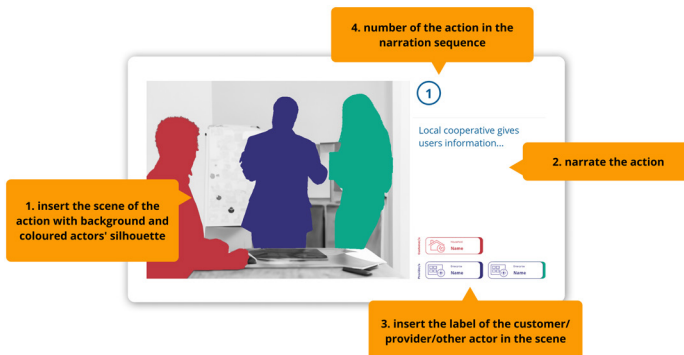


Fig. 4.82 Composition of the Stakeholders Interaction Storyboard

In case an Interaction Table has already been made (see last chapter: Interaction Table), the same images, stakeholder labels, and narrations can be used to assemble the Stakeholders Interaction Storyboard; otherwise, images can be created by following the rules in the Scene Maker. We followed the same process of replacing, but this time, we chose "Replace - Replace from the device." There are two parts to an image. Stakeholders' colours represent one, and the other is the background, representing each action's context (possibly black and white). Images can be made in many different ways.

There are 3 to introduce:

- Use the "Image Library" provided by LeNSlab Polimi to get all the elements you need to make the image
- Use the Figma template to make an image
- Use some image editing software like Photoshop or even artificial intelligence to edit or generate images.

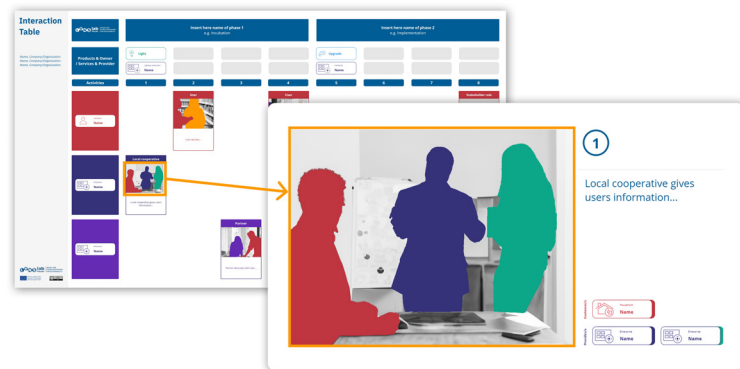


Fig. 4.83 Copying scene images from the Interaction Table and pasting into Interaction Storyboard

Actors' labels can be copied and pasted from the Interaction Table in case they're already made (Fig. 4.83). Otherwise, they can be made using this tool in the label maker (See the section in last chapter: How to use the label maker?). The labels can be copied and pasted into the Actors Legend section on the right side of the scene. Then, identify and write their names. If an icon is unavailable, the label with "other actors" can be used.



Fig. 4.84 Copying actor labels from the Interaction Table and pasting them into the Interaction Storyboard

Once labels are copied inside the Stakeholder Interaction Storyboard scene, highlight them with the respective stakeholder colour to enhance their characterization. Then, write the narrative text on the right of the scene image or copy and paste the narrative text from the Interaction Table in the same way as before. It is suggested that the narrative text be written in the third person.

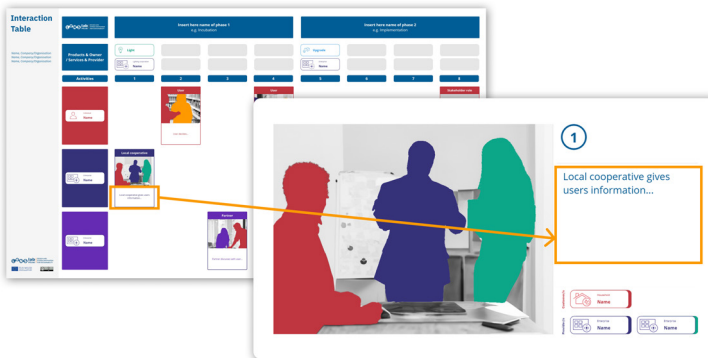


Fig. 4.85 Copying narrative text from Interaction Table and pasting into Interaction Storyboard

It is important to narrate the storyboard frame by frame, in a sequence of slides, to prepare a screen display of the interaction storyboard. In Miro (Fig. 4.87), click “Frame” in the bottom-right corner of the interface (1). Drag and drop to adjust the order in the slide bar (2). Then click “Present” to display it. Using “Talktrack,” a presentation with motion and voice can be produced and shared.



Fig. 4.86 The sequence in Interaction Storyboard (1)

If a printing version of the storyboard is requested, all the frames should remain in the same format and size in a linear order to display.

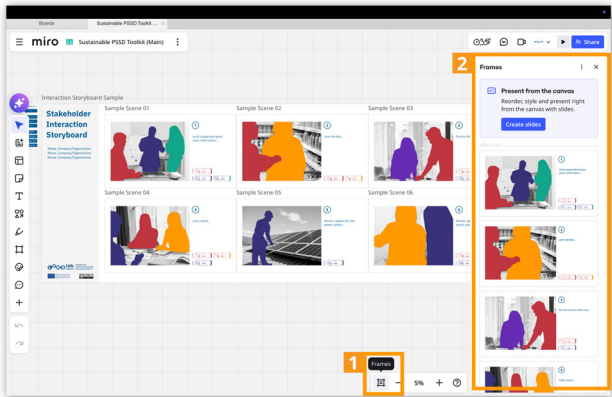


Fig. 4.87 The sequence in Interaction Storyboard (2)

Availability and Resources Required

The Stakeholders *Interaction Storyboard (Miro)*, complete with the "Image library" and the Figma image template, is an open-access tool freely available in the "Learning Resources – Tools" section of www.lenslab.polimi.it. It comes in two versions: one for screen display and one for printing. A computer and a browser compatible with the Miro collaboration platform are required to access the tool; access to Figma and/or Photoshop is also recommended. This tool requires around 60 minutes to be completed.

Similar Tools

This chapter presents the tool *Interaction Table (Miro)*. It is an updated version of the PPT- based Interaction Storyboard. Other types of Storyboards can be used.

9) Concept Evaluation – S.PSS (Miro)

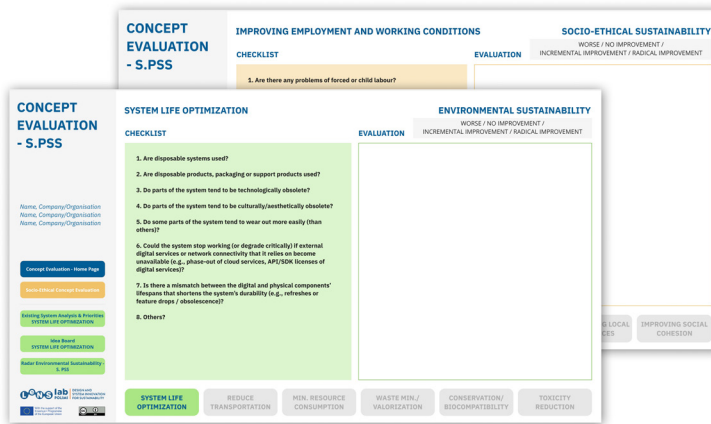


Fig. 4.88 Overview of the Concept Evaluation – S.PSS

Aim

The objective of the *Concept Evaluation – S.PSS (Miro)* is to assess potential improvements, or any worsening associated with both environmental and socio-ethical dimensions of sustainability compared to the existing system.

Components

The tool consists of: 2 sets of checklists to assess the sustainability improvement/worsening of developed system concept/s:

- Concept Evaluation Environmental Sustainability
- Concept Evaluation Socio-Ethical Sustainability

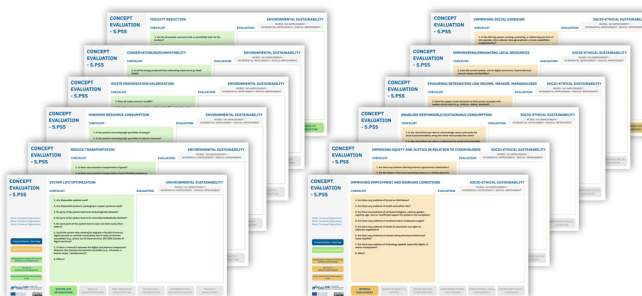


Fig. 4.89 Components of the Concept Evaluation – S.PSS

Integration Into the MSDS Design Process

The *Concept Evaluation – S.PSS (Miro)* is used within the Environmental, Socio-Ethical, and Distributed Economy Check or Visualisation phase to check and evaluate the sustainability improvements or worsening of the concept in comparison the existing system.

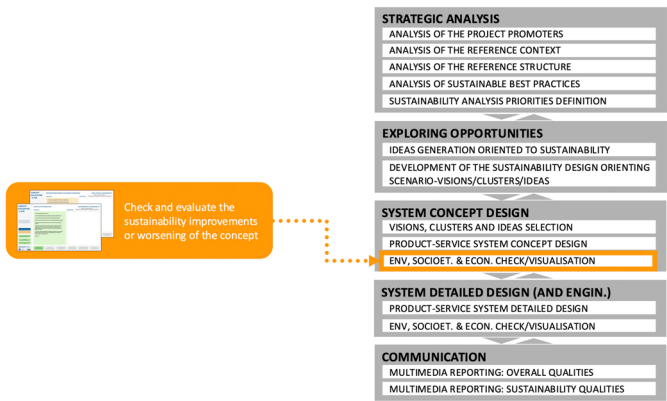


Fig. 4.90 Integrating Concept Evaluation – S.PSS into MSDS design process

How to use the *Concept Evaluation - S.PSS (Miro)*

Before Starting

The first setup process is identical to the one described in 4.2.1. After installing Miro and finding LeNSlab Polimi in Miroverse, choose *Concept Evaluation – S.PSS*.

As with all Miroverse templates, there are two ways to use this tool from the template page. One is to click “Use template”, which will create a new board with the tool in the logged-in account. Another one is to click the arrow on the right of “Use template,” then choose the existing board

in the logged-in account; Miro will automatically duplicate the tool in the existing board.

This tool has a home board (Fig. 4.91) showing essential information, a video tutorial, and shortcuts for two main sections (Environmental Concept Evaluation - S.PSS / Socio-Ethical Concept Evaluation - S.PSS).

The navigation bar on the left of each board helps users move quickly between the different boards in the tool.



Fig. 4.91 The Home board of the Concept Evaluation – S.PSS

There are two main sections in this tool. Each section has six different strategies available across different boards.

“Environmental Concept Evaluation – S.PSS” Guide

Click the arrow on the top-right corner of the “Environmental Concept Evaluation – S.PSS” button on the “Home” board.

Move there and write down the designer’s name and organization to begin using the board.

Next, select the environmental strategy to be addressed from the options available at the bottom of the board.

The screenshot displays the 'CONCEPT EVALUATION - S.PSS' interface. On the left is a sidebar with navigation buttons: 'Concept Evaluation - Home Page', 'Socio-Ethical Concept Evaluation', 'Scoring System Analysis & Priorities SYSTEM LIFE OPTIMIZATION', 'Idea Board SYSTEM LIFE OPTIMIZATION', and 'Socio-Environmental Sustainability S.PSS'. The main area is divided into three sections: 'SYSTEM LIFE OPTIMIZATION' (CHECKLIST), 'ENVIRONMENTAL SUSTAINABILITY' (EVALUATION), and a bottom navigation bar. The 'CHECKLIST' section contains eight numbered questions related to system disposability, obsolescence, and durability. The 'EVALUATION' section is a large empty box for qualitative improvement reports. The bottom bar includes buttons for 'SYSTEM LIFE OPTIMIZATION', 'REDUCE TRANSPORTATION', 'MIN. RESOURCE CONSUMPTION', 'WASTE MIN./ VALORIZATION', 'CONSERVATION/ BIOCOMPATIBILITY', and 'TOXICITY REDUCTION'.

Fig. 4.92 Selection of strategies of the Environmental Concept Evaluation - S.PSS

Then, write qualitative sustainability improvement reports for the concept in comparison to the existing system by entering the relevant information in the designated area. To support the evaluation, refer to the *“Existing System Analysis & Priorities”* board to recall previously identified problems by selecting the arrow in the top-right corner of the corresponding button in the sidebar. Return to the concept evaluation board using the button in the sidebar again.

This screenshot is identical to the one in Fig. 4.92, but with an orange rectangular box highlighting the 'EVALUATION' area in the 'ENVIRONMENTAL SUSTAINABILITY' section. Additionally, an orange box highlights the 'Scoring System Analysis & Priorities SYSTEM LIFE OPTIMIZATION' button in the sidebar, which is the button mentioned in the text for recalling previously identified problems.

Fig. 4.93 Area to write qualitative improvement report of the Environmental Concept Evaluation - S.PSS

After completing the qualitative improvement report for the selected strategy, identify the improvement level by highlighting the corresponding option in the evaluation bar located in the top-right corner of the board. Assign different colours to indicate the selected level.

Fig. 4.94 Selection of priorities of the Environmental Concept Evaluation - S.PSS

Proceed to the next strategy by selecting the top-right arrow on the button of the next strategy and repeat the same steps for each remaining strategy until all strategies are completed.

Fig. 4.95 Shortcuts to each environmental strategies of the Environmental Concept Evaluation - S.PSS

Continue by conducting the socio-ethical concept evaluation. Access the “Socio-Ethical Concept Evaluation – S.PSS” directly by selecting the corresponding button in the sidebar.

Fig. 4.96 Shortcut to Socio-Ethical Concept Evaluation - S.PSS

“Socio-Ethical Concept Evaluation – S.PSS” Guide

Follow the same step-by-step process used previously for the “Environmental Concept Evaluation – S.PSS” and apply it to each of the socio-ethical strategies in the “Socio-Ethical Concept Evaluation – S.PSS”, repeating the process until all strategies have been completed.

Availability and Resources Required

The *Concept Evaluation – S.PSS (Miro)* is an open-access tool freely available in the “Learning Resources – Tools” section of www.lenslab.polimi.it. A computer and a browser compatible with the Miro collaboration platform are required to access the tool. This tool requires at least:

- 30 minutes to evaluate the concept for all of the environmental strategies;
- 30 minutes to evaluate the concept for all of the socio-ethical strategies;

10) Radar – S.PSS (Miro)

Aim

The objective of the *Concept Evaluation – S.PSS (Miro)* is to assess potential improvements, or any worsening associated with both environmental and socio-ethical dimensions of sustainability compared to the existing system.

Components

The tool consists of: 2 sets of single summary board to visualize the sustainability improvement/worsening of developed system concept/s:

- Radar Environmental Sustainability
- Radar Socio-Ethical Sustainability

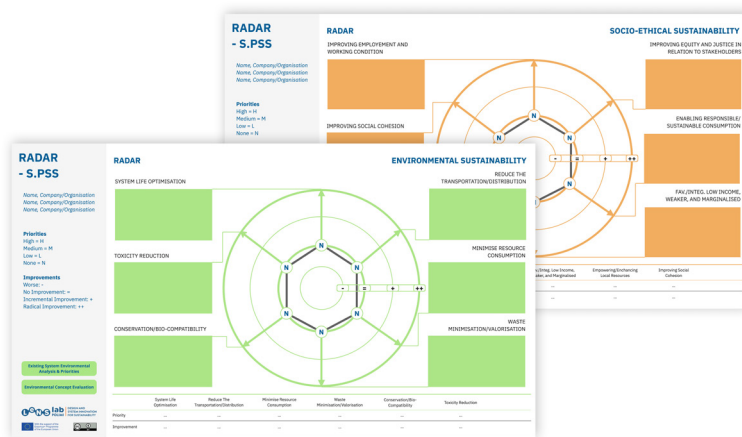


Fig. 4.97 Components of the Radar – S.PSS

Integration Into the MSDS Design Process

The *Radar – S.PSS (Miro)* is used within the Environmental, Socio-Ethical, and Distributed Economy Check or Visualisation phase to visualise the sustainability improvements or worsening of the concept in comparison the existing system.

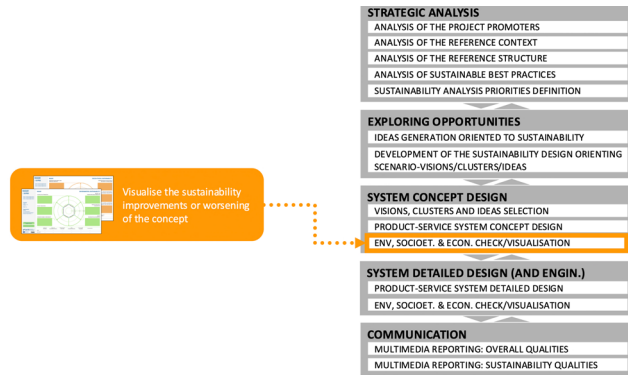


Fig. 4.98 Integrating Radar – S.PSS into MSDS design process

How to use the *Radar - S.PSS* (Miro)

Before Starting

The first setup process is identical to the one described in 4.2.1. After installing Miro and finding LeNSlab Polimi in Miroverse, choose *Radar – S.PSS*. There are two ways to use this tool from the template page. One is to click "Use Template," Miro will create a new board with the tool in the logged-in account. Another one is to click the arrow on the right of "Use Template," then choose the existing board in the logged-in account, and Miro will duplicate the tool in the existing board automatically. This tool has a home board (Fig. 4.99) showing essential information, a video tutorial, and shortcuts for two main sections (Radar Environmental Sustainability - S.PSS / Radar Socio-Ethical Sustainability - S.PSS). The navigation bar on the left of each board helps users move quickly between the different boards in the tool.

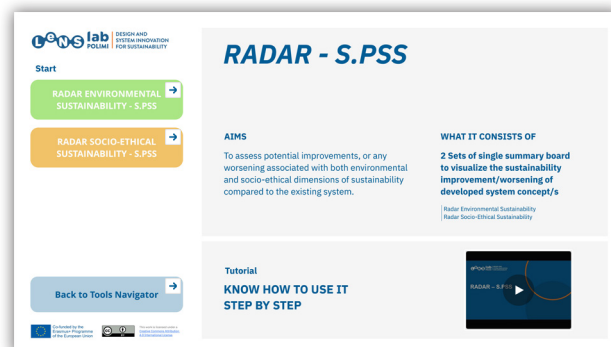


Fig. 4.99 The Home board of the Radar – S.PSS

"Radar Environmental Sustainability – S.PSS" Guide

Click the arrow on the top-right corner of the "Radar Environmental Sustainability – S.PSS" button on the "Home" board. Move there and write down the designer's name and organization to begin using the board. Remember to read the legends for priorities and improvements, which can be found on the left side of the board. First, select the environmental strategy to be addressed from the options available in the boxes. Each strategy has its own designated area to be written down.

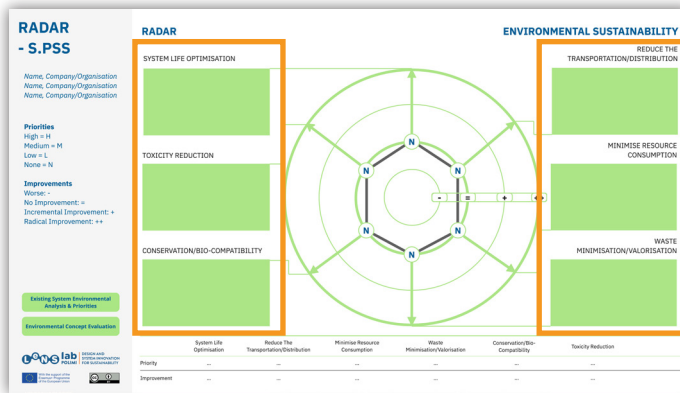


Fig. 4.100 Selection of strategies of the Radar Environmental Sustainability - S.PSS

Then, write down the summary of the qualitative sustainability improvement reports by typing the information directly in the designated area.

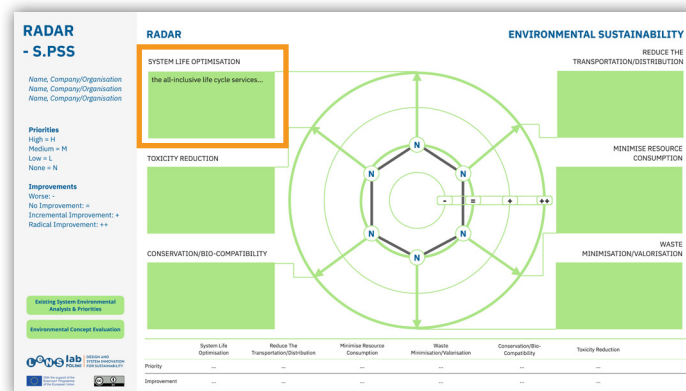


Fig. 4.101 Area to write summary of the qualitative improvement report of the Radar Environmental Sustainability - S.PSS

After that, assign the priority level by selecting one of the following options: **High (H)**, **Medium (M)**, **Low (L)**, or **None (N)**. Change the letter inside the circle according to the legend.

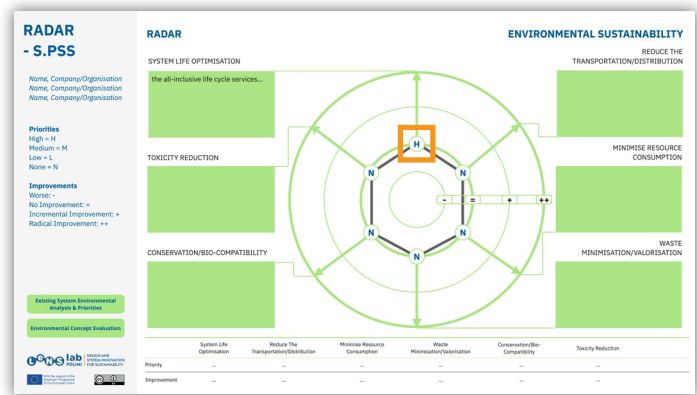


Fig. 4.102 Selection of priority levels of the Radar Environmental Sustainability- S.PSS

Next, set the improvement level by selecting one of the following options: **Worse (-)**, **No Improvement (=)**, **Incremental Improvement (+)**, or **Radical Improvement (++)**. Drag the node representing the strategy along the axis corresponding to the improvement level. The further the node is positioned along the axis, the greater the improvement level.

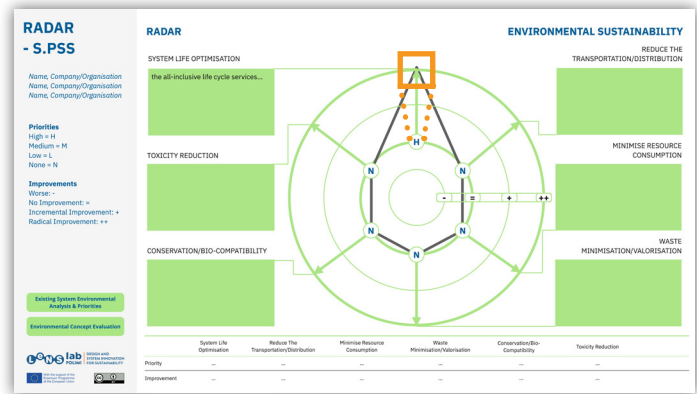


Fig. 4.103 Selection of improvement levels of the Radar Environmental Sustainability- S.PSS

For additional guidance, use the shortcut in the sidebar to recall previous assessments if the concept evaluation tool has already been completed. Select the arrow in the top-right corner of the corresponding button to access the concept evaluation board and review the previous work. Return to the radar board using the button in the sidebar again.

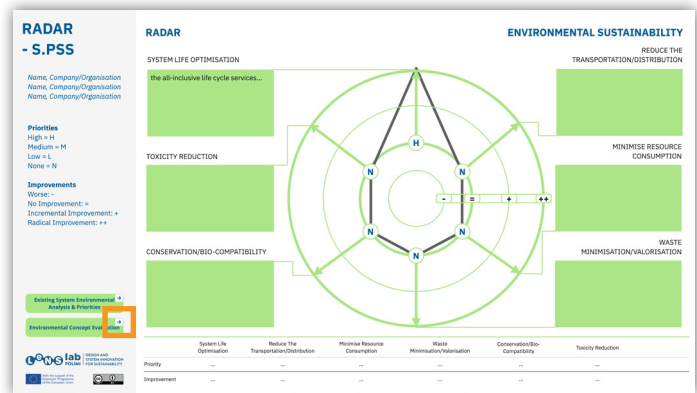


Fig. 4.104 Shortcut to Concept Evaluation - S.PSS board

Continue the process by repeating the same steps for each remaining strategy until all strategies have been completed.

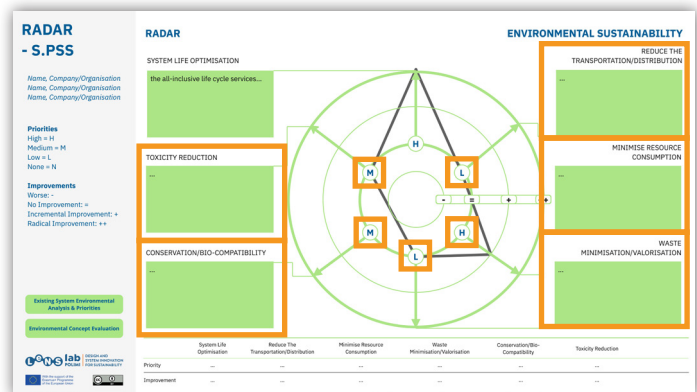


Fig. 4.105 Visualise the sustainability improvement/worsening of all strategies of the Radar Environmental Sustainability - S.PSS

After completing all strategies, fill in the table below with the data entered in the radar. Record the assessed priorities and improvement levels for each strategy in the table.

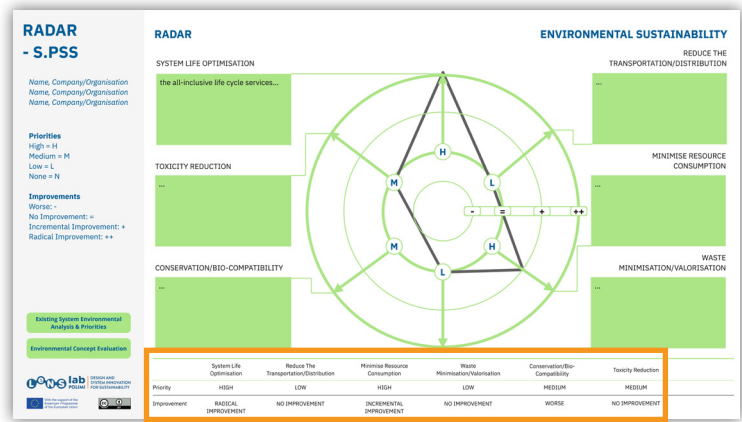


Fig. 4.106 Completing summary table of the Radar Environmental Sustainability - S.PSS

“Radar Socio-Ethical Sustainability – S.PSS” Guide

Follow the same step-by-step process used previously for the “Radar Environmental Sustainability – S.PSS” and apply it to each of the socio-ethical strategies in the “Radar Socio-Ethical Sustainability – S.PSS”, repeating the process until all strategies have been completed.

Availability and Resources Required

The Radar – S.PSS (Miro) is an open-access tool freely available in the “Learning Resources – Tools” section of www.lenslab.polimi.it. A computer and a browser compatible with the Miro collaboration platform are required to access the tool. This tool requires at least:

- 30 minutes to visualise the sustainability improvement/ worsening of the concept for all of the environmental strategies;
- 30 minutes to visualise the sustainability improvement/ worsening of the concept for all of the socio-ethical strategies;

4.2.2 Sustainability Design-Orienting (SDO) toolkit

Aim

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').

Components

The SDO is based on a spreadsheet file that integrates different tools and allows users 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)

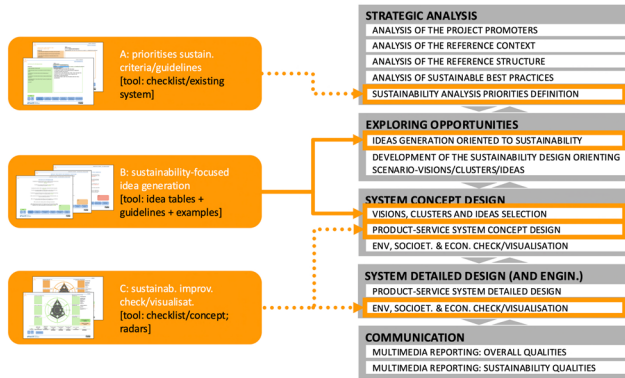


Fig. 4.107 Integrating the Sustainability Design-Orienting (SDO) toolkit into MSDS design process

How to use the *SDO toolkit*

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

Before Starting

Go to www.lenslab.polimi.it, open “Learning Resources – Tools”, click “System Design for Sustainability Tools”, and select the *SDO Sustainable Design Orienting Toolkit* video; the download link is in the video description. Begin by clicking on ‘Project record’ and fill-in your project data (Fig. 4.108).

SYSTEM DESIGN FOR SUSTAINABILITY

PROJECT RECORDS

ENVIRONMENTAL

SOCIO-ETHICAL

DISTRIBUTED EC.

ANALYSE THE EXISTING

ORIENTA

CHECK

PROJECT RECORD

PROJECT NAME

COMPANY

DESIGNERS

SATISFACTION UNIT

DESCRIPTION OF EXISTING SYSTEM

Fig. 4.108 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. “Environmental” (1) (Fig. 4.109). Next, start from “Analyse the existing system & set priorities” (2)

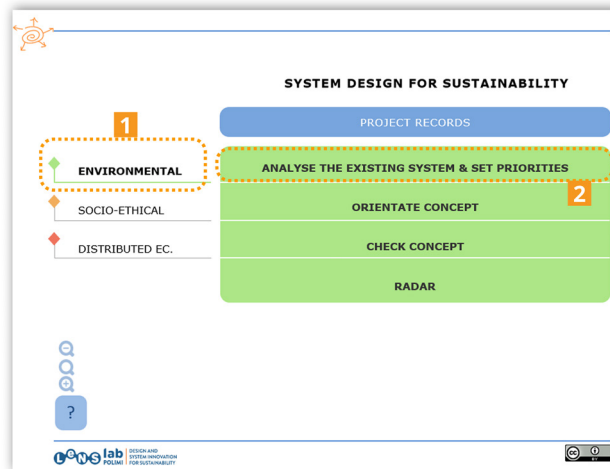


Fig. 4.109 Selection of the sustainability dimension to work on (1) and start from the analysis of the existing system (2)

Work through each strategy one by one (3), e.g., system life optimisation (Fig. 4.110), then go through the evaluation checklist (4) item by item and provide the corresponding answers (5), in order to evaluate the existing system. Once the evaluation has been completed for the entire checklist, low, medium, high, or very high priorities can be defined using the central column (6).

ANALYSE THE EXISTING SYSTEM & SET PRIORITIES

ENVIRONMENTAL

SYSTEM LIFE OPTIMISATION CHECKLIST

1. ARE DISPOSABLE SYSTEMS USED?
2. ARE DISPOSABLE PRODUCTS PACKAGING OR SUPPORT PRODUCTS USED?
3. DO PARTS OF THE SYSTEM TEND TO BE TECHNOLOGICALLY OBSOLETE?
4. DO PARTS OF THE SYSTEM TEND TO BE CULTURALLY/AESTHETICALLY OBSOLETE?
5. DO SOME PARTS OF THE SYSTEM TEND TO WEAR OUT MORE EASILY (THAN OTHERS)?
6. OTHER?

Here the answers as a report, i.e. detailing the problems

High quality of food is disposed...

Index

- SYSTEM LIFE OPTIMISATION P. 100
- REDUCE TRANSPORTATION P. 101
- MINIMISE RESOURCES CONSUMPTION P. 102
- WASTE MIN./ VALORISATION P. 103
- CONSERVATION/ RECONSTRUCTION P. 104
- TOXICITY REDUCTION P. 105

Fig. 4.110 Checklist for existing system analysis and strategies priorities setting (SDO toolkit - environmental)

B. Generate Sustainability-Focused Ideas with the Support of Existing Best Practices

The objective of S.PSS Idea Boards (Fig. 4.111) 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'.

ORIENTATE CONCEPT - ENVIRONMENTAL IDEAS BOARD

SYSTEM LIFE OPTIMISATION

Complement products/services with all inclusive services for maintenance, repair, upgrades, etc.

Complement products/services with services for sustainable repair, upgrades, etc.

Complement products/services with services for sustainable repair, upgrades, etc.

Complement products/services with services for sustainable repair, upgrades, etc.

Complement products/services with all inclusive take-back services about all or using or re-manufacturing

Offer services for shared use of resources/products/services, e.g. pay per using, pay per use

Offer services for shared ownership of a set of products, e.g. reduction purchase and use of products for multiple users

Offer services for sharing and/or exchange of products

Offer information/services for product reuse and second hand selling by providing before/after use, take-back points, direct channels for products (e.g. online marketplace of used products)

Index

- SYSTEM LIFE OPTIMISATION P. 100
- REDUCE TRANSPORTATION P. 101
- MINIMISE RESOURCES CONSUMPTION P. 102
- WASTE MIN./ VALORISATION P. 103
- CONSERVATION/ RECONSTRUCTION P. 104
- TOXICITY REDUCTION P. 105

ORIENTATE CONCEPT - SOCIOETHICAL IDEAS BOARD

IMPROVE EMPLOYMENT AND WORKING CONDITIONS

ORIENTATE CONCEPT - ENVIRONMENTAL IDEAS BOARD

CYCLE SERVICES

Financial services and repairing costs

Use for the design the generation, for the use

Use during use, i.e. the maintenance

Use for the end of life

Use to enable the users, share their own things

Index

- SYSTEM LIFE OPTIMISATION P. 100
- REDUCE TRANSPORTATION P. 101
- MINIMISE RESOURCES CONSUMPTION P. 102
- WASTE MIN./ VALORISATION P. 103
- CONSERVATION/ RECONSTRUCTION P. 104
- TOXICITY REDUCTION P. 105

Fig. 4.111 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. 4.112), select the idea boards one by one (one for each strategy) (1). Then, read the guidelines (a set for each strategy) (2) and, to facilitate the generation of ideas, have a look at the examples related to the guidelines (3). You can see and read more information 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)

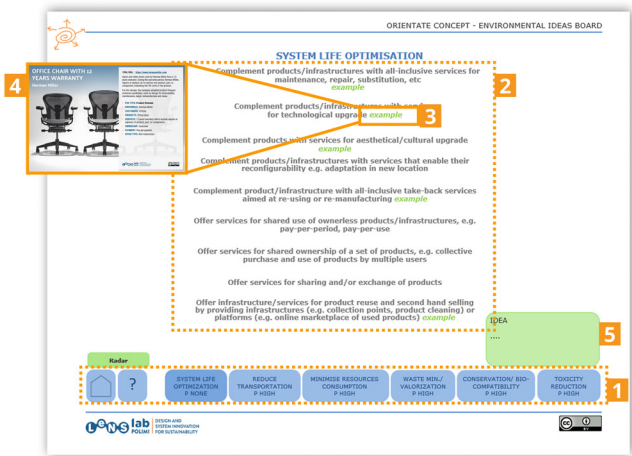


Fig. 4.112 Idea orientation and generation using the Sustainable Idea Boards

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. “Environmental” (Fig. 4.113) (1) and click on “Check concept” (2). In reference to the provided checklist for each strategy (Fig. 4.114), 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).

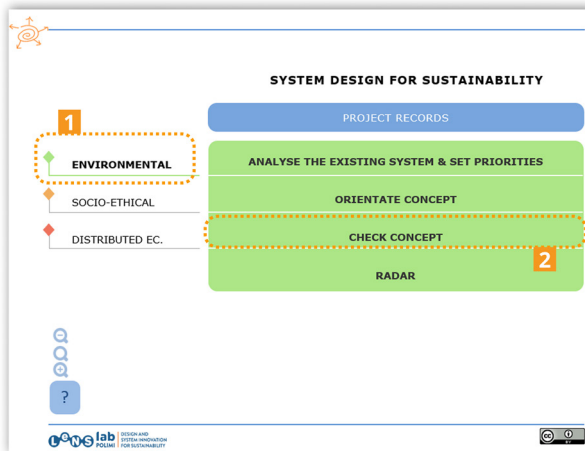


Fig. 4.113 Selection of the sustainability dimension to work on (1) and start to check concept (2)

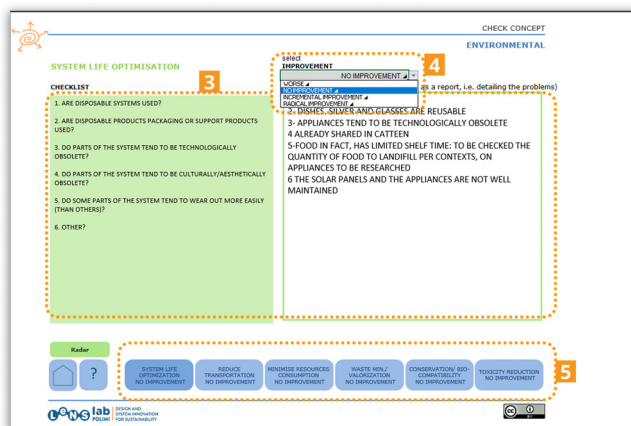


Fig. 4.114 Checklist for the system sustainability improvement evaluation (SDO toolkit - environmental)

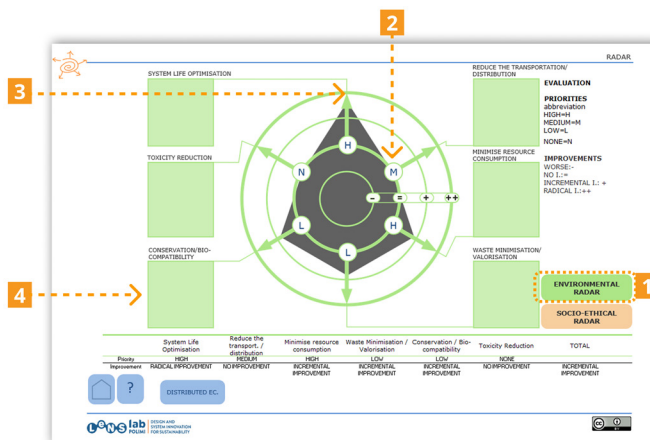


Fig. 4.115 Radar diagram (SDO toolkit - environmental)

Availability and Resources Required

The *SDO toolkit* is an open-access toolkit freely available in the “Learning Resources – Tools” section of www.lenslab.polimi.it. A computer and a spreadsheet reader are required to use the toolkit. This toolkit requires at least: 45-90 minutes to for the sustainability evaluation; 60-180 minutes to generate ideas in the idea boards; 30-60 minutes to check the improvement on the radar.

Similar Tools

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 Stakeholders Motivation and Sustainability Table

Aim

The objective of the Stakeholders Motivation and Sustainability Table (Fig. 4.116) 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.

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

Stakeholders' Motivation and Sustainability Table

Name, Company/Organization
Name, Company/Organization
Name, Company/Organization

GENESlab European Union Horizon 2020 Marie Skłodowska Curie Grant Agreement 101019719

Fig. 4.116 Stakeholders Motivation and Sustainability Table

Components

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. 4.117). 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.

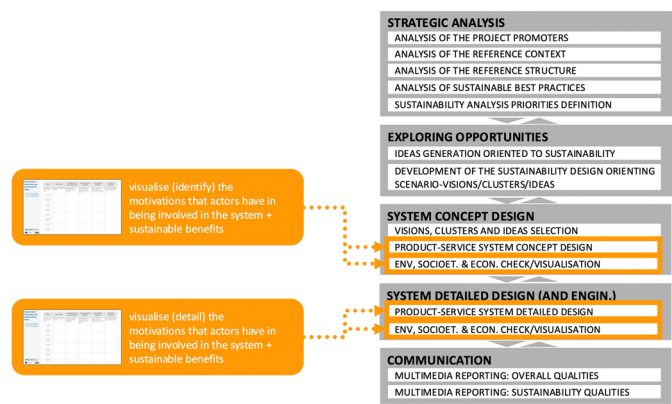


Fig. 4.117 Integration of the Stakeholders Motivation and Sustainability Table within the MSDS method

How to use *Stakeholders Motivation and Sustainability Table*

Go to www.lenslab.polimi.it, open “Learning Resources – Tools”, click “System Design for Sustainability Tools”, and select the *Stakeholders Motivation and Sustainability Table* video; the download link is in the video description. The following steps must be undertaken to use the tool:

- Identification and positioning of actors in the header column (Fig. 4.118):
- 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. 4.119).
- 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. 4.120)
- Write the contribution of each actor to the platform (Fig. 4.121)

Actors	Motivation	Contribution to the partnership	Environmental Benefits	Socio-ethical Benefits	Economic Benefits
Place below the icon of the actor and the name of the actor			Write the criteria in the next slides to describe the potential environmental fits (given by each actor)	Read the criteria in the next slides to describe the potential socio-ethical benefits (given by each actor)	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. 4.118 Stakeholders Motivation and Sustainability Table: actors' column

- Write the potential environmental benefits they can promote within the system (Fig. 4.122)
- Write the potential socio-ethical benefits they can promote within the system (Fig. 4.123)
- Write the potential economic benefits they can promote within the system (Fig. 4.124)

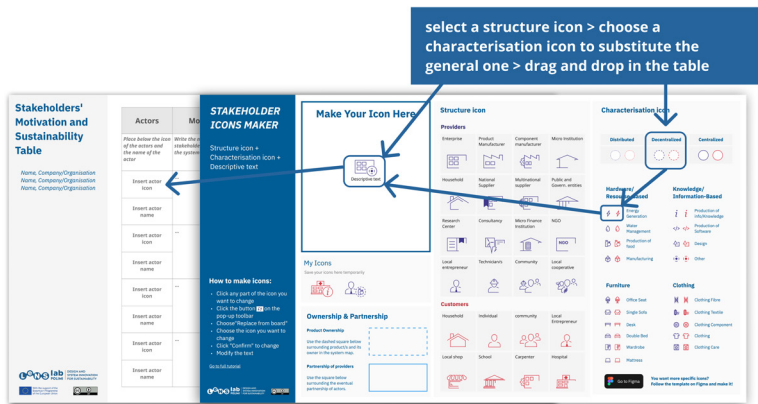


Fig. 4.119 Selection and combination process of actors' icons

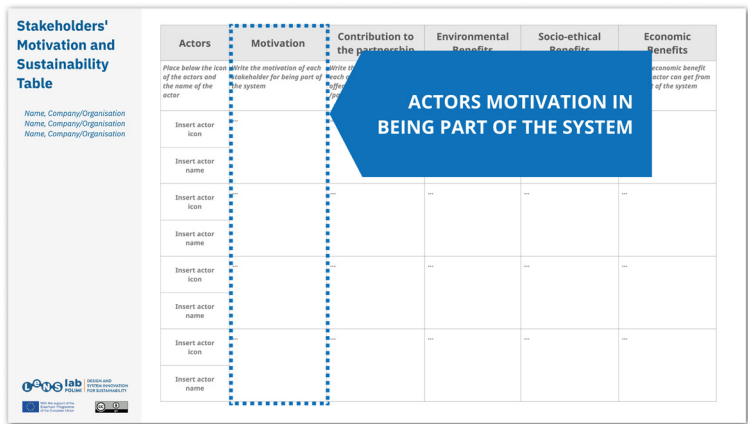


Fig. 4.120 Actors' motivation (Stakeholders Motivation and Sustainability Table)

Stakeholders' Motivation and Sustainability Table

Name, Company/Organisation
Name, Company/Organisation
Name, Company/Organisation

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

CONTRIBUTE THE SINGLE ACTORS GIVE TO THE WHOLE PARTNERSHIP

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Fig. 4.121 Actors' contribution to the partnership (Stakeholders Motivation and Sustainability Table)

Stakeholders' Motivation and Sustainability Table

Name, Company/Organisation
Name, Company/Organisation
Name, Company/Organisation

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

ACTORS ENVIRONMENTAL BENEFITS FOR THE SYSTEM OFFER

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Environmental check-lists

System life optimization
Are infrastructure with short life-span used in the system?
Are disposable packaging or support product used?
Do part of the system tend to be technologically obsolete?

Fig. 4.122 Actors' environmental benefits for the system offer (Stakeholders Motivation and Sustainability Table)

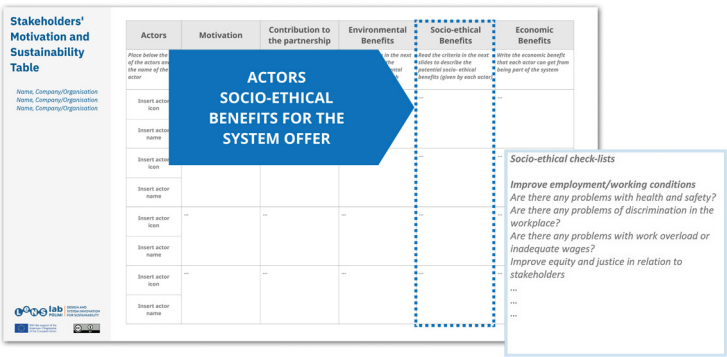


Fig. 4.123 Actors' socio-ethical benefits for the system offer (Stakeholders Motivation and Sustainability Table)

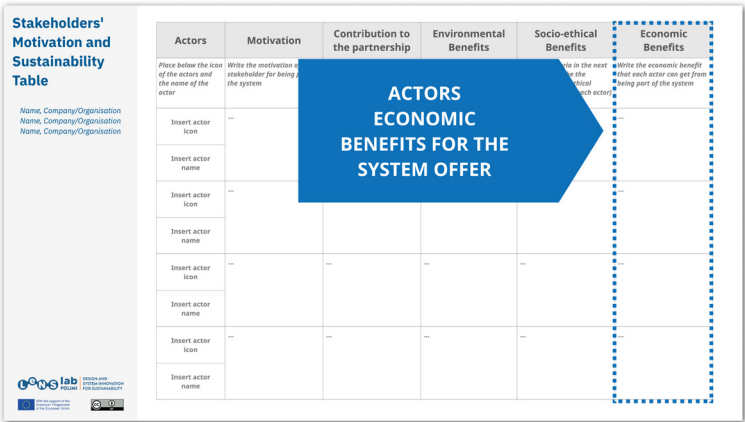


Fig. 4.124 Actors' economic benefits for the system offer (Stakeholders Motivation and Sustainability Table)

Availability and Resources Required

Stakeholders Motivation and Sustainability Table is an open-access tool freely available in the “Learning Resources – Tools” section of www.lenslab.polimi.it. A computer and a PowerPoint reader are required to access the tool. This tool requires at least 45 minutes to be completed.

4.2.4 Satisfaction Offering Diagram

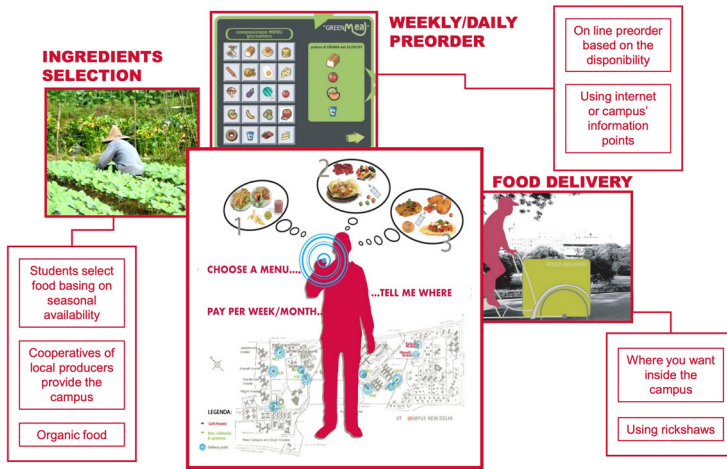


Fig. 4.125 Satisfaction Offering Diagram

Aim

The objective of the *Satisfaction Offering Diagram* (Fig. 4.125) is to describe in brief the satisfaction offered to the user/customer, and how this is delivered.

Components

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. 4.126):

- 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.

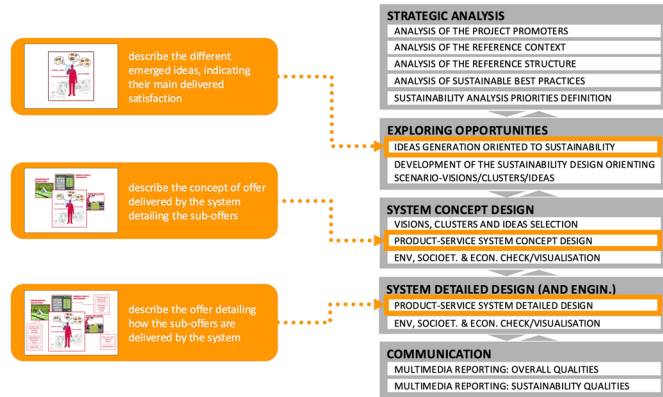


Fig. 4.126 Integration of the Satisfaction Offering Diagram within the MSDS methodology

How to use *Satisfaction Offering Diagram*

Go to www.lenslab.polimi.it, open “Learning Resources – Tools”, click “System Design for Sustainability Tools”, and select the *Satisfaction Offering Diagram* video; the download link is in the video description. 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. 4.127). 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. 4.128).

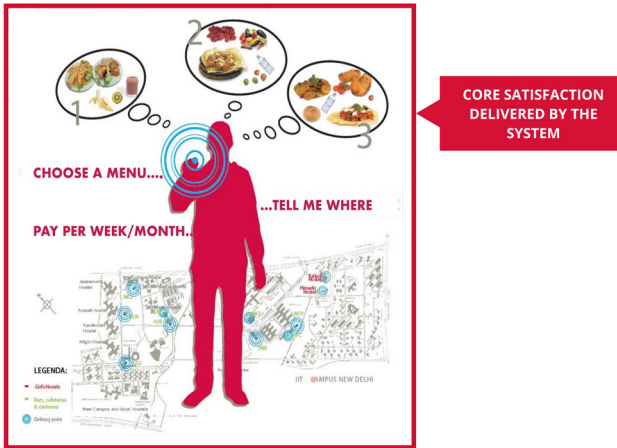


Fig. 4.127 Satisfaction offering diagram: the core satisfaction



Fig. 4.128 Satisfaction offering diagram: the sub-offer and its description

Availability and Resources Required

The *Satisfaction Offering Diagram* is an open-access tool freely available in the “Learning Resources – Tools” section of www.lenslab.polimi.it. A computer and graphics software, such as Photoshop, Illustrator, Figma or PowerPoint, are required to use the tool. This tool requires around 60 minutes to be completed.

4.2.5 Animatic for S.PSS and DE

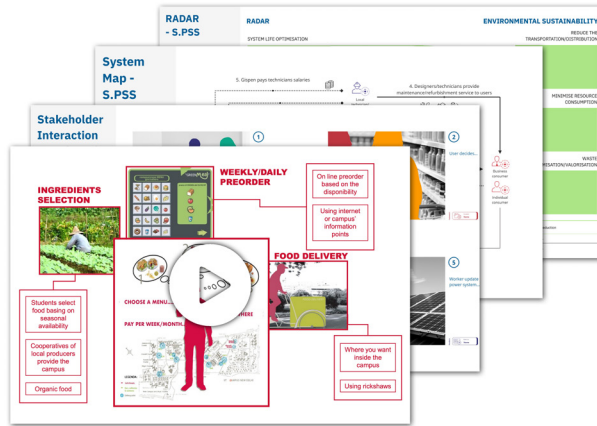


Fig. 4.129 Animatic for S.PSS and DE

Aim

The objective of the *Animatic for S.PSS and DE* (Fig. 4.129) 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).

Components

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 benefits.

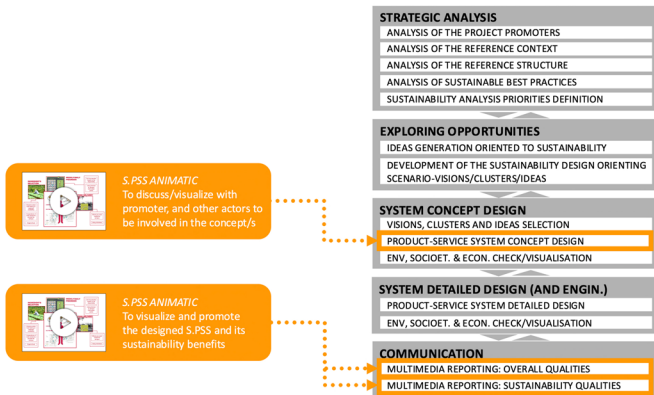


Fig. 4.130 Integration of the Animatic for S.PSS and DE within the MSDS method

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. 4.131)

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.

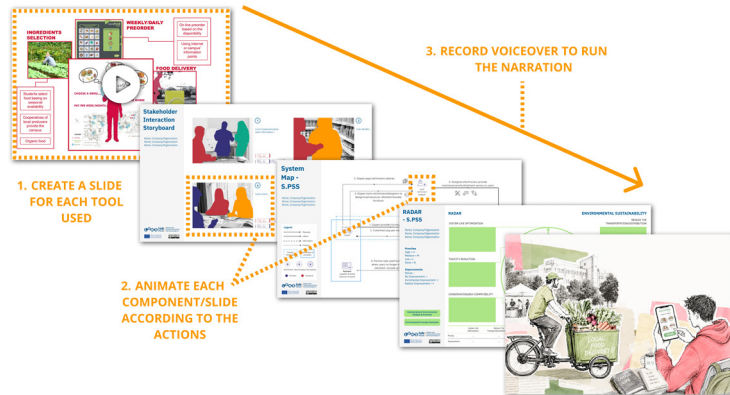


Fig. 4.131 Elements for the creation of the Animatic for S.PSS and DE slideshow

To produce a good-quality *Animatic for S.PSS and DE*, the following suggestions should be followed:

- Make a 3-minute animatic, up to a maximum of 5 minutes;
- Record the animatic with a good-quality audio;
- Avoid recording during transitions between slides;
- Ensure that the animatic is understandable to external evaluators.

Availability and Resources Required

The *Animatic for S.PSS and DE* is an open-access tool freely available in the “Learning Resources – Tools” section of www.lenslab.polimi.it. A computer and PowerPoint reader are required to use the tool; video-editing software, such as Adobe Premiere Pro or Adobe After Effects, may support the editing phase. This tool requires at least 120 minutes to be completed.

4.2.6 E.DG — Estimator for Distributed energy Generation

Aim

This tool was developed to support the design of Distributed energy Generation (DG, formerly known as DRE) systems (Vezzoli, Bacchetti and Ceschin, 2018), 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. 4.132).



Fig. 4.132 S.PSS and DG estimator of DG load/need and production potential. Source designed by the Authors

Components

The tool is composed of six 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 it 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.
4. 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. 4.133, 4.134, 4.135 and 4.136).

PHOTOVOLTAIC ENERGY SYSTEM SIZING

Site

MONTHLY GLOBAL SOLAR RADIATION (kWh/m²/day)
 How to get the minimum solar radiation value
 In-circuit efficiency (kWh/m²/year)
 select PV module type ...
 Average of system losses (BOS) (Balance of System efficiency) (kWh/m²/year)
 (kWh/m²/year is possible, incorrect)

Incination
 Orientation
 (Azimuth angle from -180 to 180, East=90)

STARTING FROM YOUR ENERGY LOADED

E = ENERGY NEED (kWh/year) 0
 B = NORMAL POWER (kWp) 0.00
 S = SURFACE NEEDED (m²) 0.00
 AVERAGE COST OF THE SYSTEM (€) 0.00

Do you have an available surface different from the one calculated?

S = AVAILABLE SURFACE (m²) 0.00
 B = NORMAL POWER (kWp) 0.00
 E = ESTIMATED ENERGY PRODUCTION (kWh/year) 0.00
 AVERAGE COST OF THE SYSTEM (€) 0.00

Do you have a less or greater budget than that calculated?

B = BUDGET (€) 0.00
 B = NORMAL POWER (kWp) 0.00
 E = ESTIMATED ENERGY PRODUCTION (kWh/year) 0.00
 S = SURFACE NEEDED (m²) 0.00

BOS Losses details
 (depend of site, technology, and energy of the system)

Inverter losses (P _{inv} to P _{DC})	8%	Global formula: $E = S \cdot \eta_{PV} \cdot H \cdot \eta_{BOS}$
Temperature losses (P _{DC} to P _{AC})	8%	Legend
DC cables losses (P _{DC} to P _{inv})	2%	Enter your own data
AC cables losses (P _{AC} to P _{inv})	2%	Result (do not change the value)
Shading (P _{DC} to P _{DC}) (depends of site)	3%	Calculated value (do not change the value)
Losses-wire insulation (P _{DC} to P _{AC})	3%	
Losses due to dust, snow, etc. (P _{DC})	2%	
Other Losses	0%	

Is your system off-grid?

INVERTER SIZE (kW) 0.0
 AC/DC ratio 0.0
 ENERGY DAILY USAGE (kWh) 0.0
 DAYS OF AUTONOMY (suggested from 2 to 5 days)
 SYSTEM VOLTAGE
 Small (48V loads) 3.3kV - 12V
 Intermediate (48V loads) 3.3kV - 24V
 Large loads 3.3kV - 48V
 MAXIMUM DEPTH OF DISCHARGE (DOD) 0.6
 BATTERY BANK CAPACITY (kWh) 0.0
 NUMBERS OF BATTERIES 0
 BATTERY TYPE Lead-acid
 AVERAGE COST OF THE BATTERY (€) 0.00

source: Technical Design Guidelines On Grid PV Systems, IRENA

the Learning Network on Sustainable Energy Systems

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START ENERGY NEED PRODUCTION ELAP POWER CONSUMPTION DATABASE PV SYSTEM SIZING WIND SYSTEM SIZING HYDRO SYSTEM SIZING BIOGAS DIGESTER SIZING REFERENCES

Fig. 4.133 Worksheet—solar energy. Source designed by the Authors

WIND ENERGY SYSTEM SIZING

Site

WIND SPEED (m/s) 1.20
 How to get the wind speed value
 POWER COEFFICIENT (between 0.2 and 0.6) the maximum power that can be extracted from the wind according to Betz is 59.3 %

STARTING FROM YOUR ENERGY LOADED

E = ENERGY NEED (kWh/year) 0.00
 POWER TURBINE (kW) 0.00
 BLADE LENGTH (m) 0.00
 TURBINE HEIGHT (m) 0.00
 NUMBER OF TURBINES 0.00
 ENERGY ESTIMATED PRODUCTION (kWh/year) 0.00
 AVERAGE COST OF THE SYSTEM (€) 0.00

STARTING FROM YOUR BLADE LENGTH

BLADE LENGTH (m) 0.00
 CH max radius suggested per turbine (m) 0.00000
 TURBINE HEIGHT (m) 0.00000
 POWER TURBINE (kW) 0.00
 ENERGY ESTIMATED PRODUCTION (kWh/year) 0.00
 TOTAL ENERGY ESTIMATED PRODUCTION (kWh/year) 0.00
 AVERAGE COST OF THE SYSTEM (€) 0.00

Classification of wind resource by wind speed range

Class	Wind Speed (m/s)	Wind Speed (mph)
Marginal	4 to 5	9 to 11.2
Fair	5 to 6	11.2 to 13.6
Good	6 to 7	13.6 to 15.8
Excellent	7 to 8	15.8 to 18
Outstanding	over 8	Over 18

Is your system off-grid?

INVERTER SIZE (kW) 0.0
 AC/DC ratio 0.0
 DAILY ENERGY LOAD (kWh) 0.0
 DAYS OF AUTONOMY (suggested from 2 to 5 days)
 SYSTEM VOLTAGE
 Small (48V loads) 3.3kV - 12V
 Intermediate (48V loads) 3.3kV - 24V
 Large loads 3.3kV - 48V
 MAXIMUM DEPTH OF DISCHARGE (DOD) 0.6
 BATTERY BANK CAPACITY (kWh) 0.0
 NUMBERS OF BATTERIES 0
 BATTERY TYPE Lead-acid
 AVERAGE COST OF THE BATTERY (€) 0.00

source: Technical Design Guidelines On Grid PV Systems, IRENA

the Learning Network on Sustainable Energy Systems

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START ENERGY NEED PRODUCTION ELAP POWER CONSUMPTION DATABASE PV SYSTEM SIZING WIND SYSTEM SIZING HYDRO SYSTEM SIZING BIOGAS DIGESTER SIZING REFERENCES

Fig. 4.134 Worksheet—wind energy. Source designed by the Authors

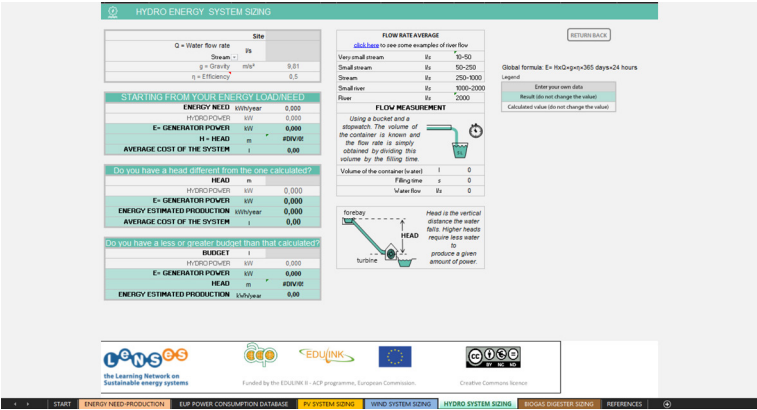


Fig. 4.135 Worksheet—hydro energy. Source designed by the Authors

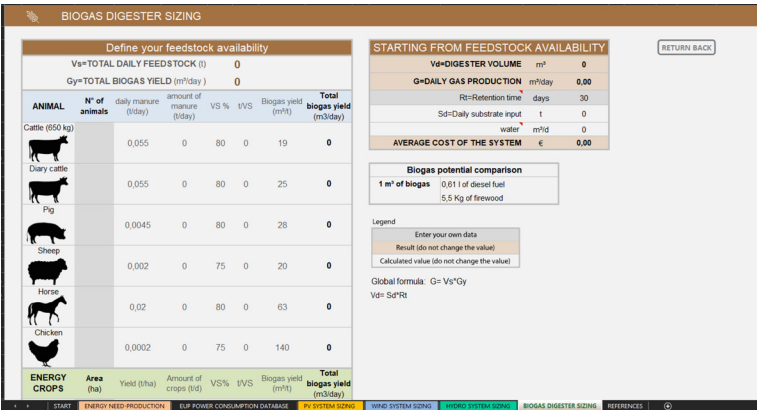


Fig. 4.136 Worksheet—biomass energy. Source designed by the Authors

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.

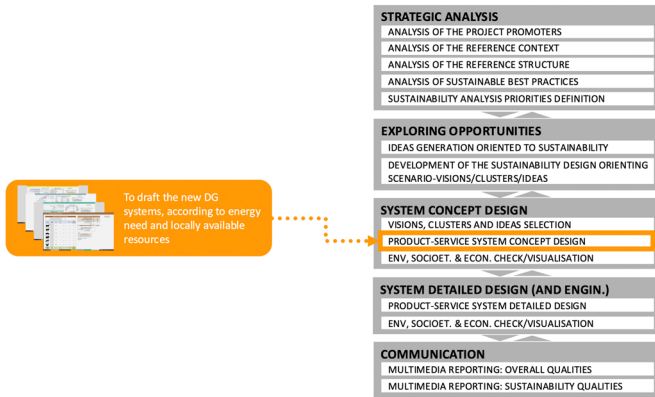


Fig. 4.137 Estimator for Distributed energy Generation's integration into the MSDS design process

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.

Availability and Resources Required

The *Estimator for Distributed energy Generation* is an open-access tool freely available in the “Learning Resources – Tools” section of www.lenslab.polimi.it. A computer, a spreadsheet reader and an internet connection are required to use the tool and connect to online databases. The tool requires at least 60 minutes to complete.

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The transition towards sustainability requires radical changes in the way we produce, consume and live. System innovations are therefore necessary to support sustainable transitions. The aim of this book is to describe and support the practice of System Design for Sustainability (SDS), focusing on two promising models: Sustainable Product-Service Systems (S.PSS) and Distributed Economies (DE).

Sustainable Product-Service Systems offer win-win opportunities by combining economic, environmental and socio-ethical sustainability. Distributed Economies are promising models for locally based and resilient sustainability. When coupled and appropriately designed, they can result in resilient solutions that reduce environmental impact and generate economic benefits for providers, while extending access to goods and services to low- and middle-income contexts.

The book provides a comprehensive overview of the practice of designing Sustainable Product-Service Systems applied to Distributed Economies. It describes practical strategies, guidelines and examples to support the design of environmentally, socially and economically sustainable Product-Service Systems. It also presents strategies and guidelines for designing Distributed Economies as Sustainable Product-Service Systems.

Finally, the book presents the Method for System Design for Sustainability (MSDS) and its main tools, developed to support designers in the design of S.PSS and DE.

This 2nd edition has been substantially revised, with updated data, cases and digital tools.

Carlo Vezzoli is Full Professor at the Department of Design, Politecnico di Milano, where he has researched and taught product and system design for sustainability for more than 25 years, as coordinator of the LeNSlab research group. In 2007, he founded the Learning Network on Sustainability (LeNS), a worldwide, multipolar network of more than 160 design universities across all continents, dedicated to spreading design for sustainability through an open-access ethos. In 2021 he was awarded the title of PhD Honoris Causa by the Federal University of Paraná.

Hang Su is a PhD researcher at LeNSlab. His research lies at the intersection of digital transformation and design for sustainability, with a specific focus on exploring and designing the nexus between smart mobile device systems (SMDS) and sustainable product-service systems (S.PSS) to promote environmentally and economically sustainable innovation. As a design practitioner, he also has expertise in life cycle design, sustainable system innovation, service design and speculative/critical design.

Alessandra Caroline Canfield Petrecca is a design researcher with experience spanning academia, consultancy and interdisciplinary projects. She holds a PhD in Design from Politecnico di Milano, where her research at LeNSlab focused on design strategies for preserving user agency and developing socio-ethically sustainable digital systems. Her interests include sustainable innovation, service and systems design, digital ethics, personal data governance and responsible technology.

Gabriele Tempesta is a design consultant specialising in design for sustainability and human-centred design, with a decade of professional experience in China. He is an alumnus of Politecnico di Milano, where he is a PhD researcher and operational manager of LeNSlab. His research explores how academic consultancies can effectively support the organisational adoption of sustainable product and system design. He is also an experienced public speaker, having delivered 60+ talks since 2015.