

Method and tools for system design for sustainable energy for all

Vezzoli, Carlo; Ceschin, Fabrizio; Osanjo, Lilac; M'Rithaa, Mugendi K.; Moalosi, Richie; Nakazibwe, Venny; Diehl, Jan Carel

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Chapter 7

Method and Tools for System Design for Sustainable Energy for All



7.1 Method for System Design for Sustainable Energy for All

The method developed within the LeNSes project is called Method for System Design for Sustainable Energy for All (MSD4SEA). It came out as one of the results of the project, but it is based on other methods and tools developed formerly under other EU funded researches.

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

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

- Procedural stages: all the stages can be used or certain stages can be selected according to the requirements of the project;
- Tools to use: the method is accompanied by a series of tools (many of them elaborated within the same LeNSes project). It is possible to select which of these to use during the design process;
- 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 requirements of the design project.

The basic structure of method consists of four main stages.

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

A further stage is added, across the others, to draw up documents to report on the sustainability characteristics of the solution designed, namely:

- Communication.

The following Table 7.1 shows the aims, the processes and the tools for each stage of the method.

Table 7.1 Stages, aims, processes and tools for each stage of the method for SD4SEA

Aims	Processes	Tools
<i>Strategic analysis (SA)</i>		
To obtain information to facilitate the generation of S.PSS applied to DRE systems	Analyse project proposers and reference context and general macro-trends	<ul style="list-style-type: none"> – Innovation diagram for S.PSS and DRE – Energy System map – S.PSS + DRE innovation map – Strategic analysis (SA) template – MiniDOC – SWOT matrix
	Analyse sustainability of existing system and set priorities for the design intervention	<ul style="list-style-type: none"> – Strategic analysis (SA) template – S.PSS + DRE innovation map – Sustainability design orienting (SDO) toolkit
	Analyse access to energy in the context of reference	<ul style="list-style-type: none"> – Strategic analysis (SA) template – Resources assessment software – Sustainability design orienting (SDO) toolkit
	Analyse sustainable best practices	<ul style="list-style-type: none"> – Energy system map – S.PSS&DRE case study format – Sustainability design orienting (SDO) toolkit – MiniDOC

(continued)

Table 7.1 (continued)

Aims	Processes	Tools
<i>Exploring opportunities</i>		
To make a 'catalogue' of promising opportunities towards S.PSS applied to DRE	Generate sustainability-oriented ideas at system/stakeholder level	<ul style="list-style-type: none"> - Offering diagram - Sustainability design orienting (SDO) toolkit - Satisfaction system map
	Generate DRE oriented ideas at system/stakeholder level	<ul style="list-style-type: none"> - Sustainability design orienting scenario for S.PSS&DRE - Sustainable energy for all idea tables (and cards) - S.PSS + DRE design framework and cards
	Outline a sustainable design orienting scenario	<ul style="list-style-type: none"> - Sustainability design orienting scenario - S.PSS + DRE innovation map
<i>Design system concepts</i>		
To determine one or more system concepts oriented towards S.PSS applied to DRE	Select clusters and single ideas (environmental, socioethical, DRE-oriented)	<ul style="list-style-type: none"> - Innovation diagram for S.PSS and DRE
	Develop system concept/s	<ul style="list-style-type: none"> - Energy system map - PSS + DRE Design framework and cards - Estimator of DRE (E.DRE) - Concept description form for S.PSS and DRE - Stakeholder's motivation and sustainability table - Offering diagram - Interaction table - Interaction storyboard - System concept audiovisual
	Environmental, socioethical, and economic assessment of system concept/s	<ul style="list-style-type: none"> - Sustainability design orienting (SDO) toolkit - Sustainability interaction story-spot
	Evaluate the system concept/s	<ul style="list-style-type: none"> - Stakeholder's motivation and sustainability table

(continued)

Table 7.1 (continued)

Aims	Processes	Tools
<i>Design system details</i>		
To develop the most promising system concept into the detailed version ready for implementation	Detail the system	<ul style="list-style-type: none"> – Energy system map – Offering diagram – Interaction table – Interaction storyboard – Stakeholder’s motivation and sustainability table – Solution element brief – Business plan
	Environmental, socioethical, and economic assessment of DRE system	<ul style="list-style-type: none"> – Sustainability design orienting (SDO) toolkit
	Present/discuss the system developed, e.g. outline main activities characteristics, actors	<ul style="list-style-type: none"> – Sustainability interaction story-spot – Animatic
<i>Communication</i>		
To communicate (internally/externally) the general and (above all) sustainable characteristics of the system designed	Draw up the documentation for (internal) communication	<ul style="list-style-type: none"> – Sustainability design orienting (SDO) toolkit – MiniDOC
	Draw up the documentation for (external) communication	<ul style="list-style-type: none"> – Animatic – Energy system map – Offering diagram – Interaction story-spot – Sustainability design orienting (SDO) toolkit

Source designed by the Authors

The following sections present each stage describing its component processes. Attention is paid to sustainability-orienting processes.

Strategic Analysis

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

Analyse project promoters and outline the intervention context

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

Key questions:

- What is the demand/satisfaction unit to be met?
- What are the key areas of expertise of the project promoters?
- What are their main strengths and weaknesses?
- Who are the main actors? What is the relationship between them?
- What are the main environmental, socioethical and economic problems associated with the value chain?
- What is the value for the customer?

Analysing the context of reference

The aim of this activity is to analyse the context, or rather the sociotechnical regime, of which the innovation will become a part. First, the structure of the production and consumption system (the scope of intervention) is analysed: what actors come into play (companies, institutions, NGOs, consumers, etc.) and what the relationships are between them, as well as what specific dynamics (technological, cultural, economic and regulatory) characterise the system itself. Special attention is also paid to current and potential competitors (analysing their characteristics and offers) and to customers (analysing their needs).

Key questions:

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

Analysing the carrying structure of the system

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

Key question:

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

Analysing cases of sustainable energy access

The aim of this activity is to analyse in detail cases of excellence that could act as a stimulus during the generation of ideas. The result will be a document summarising the offer for each case of excellence, the interactions with the user, the offer producers and providers, and its sustainability characteristics.

Key questions:

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

Analysing the context energy access

The aim of this activity is to analyse the access to (renewable and non-renewable) energy sources within the context where the existing offer is given.

Key questions:

- How is energy delivered (Country/region energy plan/local policies for energy access)?
 - Within the country/region?
 - Within the specific design context?

- Which are the main energy sources used? (Renewable/non-renewable)
 - Within the country/region?
 - Within the specific design context?
- Why some areas donot have energy? How they currently supply energy need?
- If energy provision is not guaranteed/legal, how the users currently supply energy need in the design context?
 - In the country/region?
 - In the specific design context?
- What is the average electricity consumption of households per capita?
 - In the country/region?
 - In the specific design context?
- Who, between men and women, has the control on the energy use in the specific design context?
- Which is the availability and capacity of renewable energy resources)?
 - In the country/region?
 - In the specific design context?

Analysing sustainability of existing system and determine priorities for the design intervention in view of sustainable energy solutions and sustainability more in general

The aim of this activity is to analyse the existing energy system in the design context from environmental, socioethical and economic point of view in order to identify the design priorities (in other words, to understand where it is most important to intervene in order to reduce the environmental, socioethical and economic impact of the existing energy system). This operation is fundamental to steering the design process towards the solutions that are the most able to foster Sustainable Energy for All. The result will be a document summarising the energy system analysis and its environmental, socioethical design priorities.

Key questions:

- What is the situation in the design context regarding the existing energy system and its environmental, socioethical and economic sustainability?
- What are the design priorities for each dimension of sustainability?

Exploring opportunities

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

It must be stressed that the aim of this stage is not to come up with incremental improvements at product level, but rather to come up with possible innovations at system level, characterised by radical improvements from an environmental, socioethical and economic point of view.

The specific aim is therefore to use all the information collected and processed during the previous stage to outline a ‘catalogue’ of promising strategic S.PSS applied to DRE opportunities.

Generate sustainability-oriented ideas

On the basis of the information previously acquired, a set of potentially sustainable ideas is generated through an idea-generating workshop. It must be made clear that the idea generation must be orientated towards satisfying a specific satisfaction unit. In this sense, particular attention is paid to coming up with system level ideas, i.e. ideas regarding the configuration of actors able to produce/deliver that offer (satisfaction unit); and the products and services that constitute the offer. Special design guidelines have been drawn up to steer idea generation towards sustainable system solutions. It is also useful to have a collection of cases of excellence available as a further stimulus, and a map of the actors who may potentially become part of the *satisfaction system*. The result of this process will be a document listing the satisfaction unit and a set of system ideas with their environmental, socioethical and economic sustainability characteristics.

Key questions:

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

Generate Energy for All-oriented ideas

The aim of this process is to orientate system idea generation design process towards promising Sustainable Energy for All solutions. Generally, ideas are generated through workshops, starting with the definition of the energy satisfaction unit to be met by design.

Specify the Sustainable Energy for All design-oriented scenario

The aim of this stage is to specify in relation to the context, the providers and the satisfaction unit, the Sustainable Energy for All design orienting scenario, the scenario is composed of a set of visions, or better, possible promising Sustainable Energy for All design orientations.

The aim of this process is to select, map and cluster most promising ideas previously generated and place them in the Innovation Diagram for S.PSS & DRE tool, then generate new ideas to move from one polarity to another one generating further promising ideas.

System Concept Design

The aim of this stage is to select the most promising clusters and single ideas and design one or more system concepts oriented towards S.PSS applied to DRE solutions.

Selecting clusters of ideas and/or single ideas

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

Key questions:

- Which ideas are the most promising from an economic point of view and in terms of provider's competences and customer acceptability?
- Which ideas are most promising from an environmental and socioethical point of view?

System Concepts development

One or more system concepts will emerge from the combinations of ideas previously singled out. The following elements are then defined for each of these system concepts: the set of products and services that make up the offer and the functions it fulfills; the actor system (primary and secondary) that produces and delivers the offer; and the interaction between various stakeholders of the satisfaction system.

Key questions:

- What products and services make up the offer? What functions does it fulfill? What is the value perceived by the user? How does the customer interact with the offer system?
- Who are the socio-economic actors of the system and what are their interactions? Which are the principal and which the secondary actors?

DRE System Concept Design

The aim of this process is to select the most appropriate renewable energy resource available in the context in which will be implemented the design solution and to estimate, according to the user-energy need, the size of the DRE.

Environmental, socioethical and economic assessment

The aim of this process is to assess the potential improvements that the system concepts could generate from an environmental, socioethical and economic point of view. This process is fundamental in order to understand whether there are still any unresolved critical points and also, if more than one concept has been developed, to decide which one is more promising. The result will be a description, for each concept, of the potential improvements offered (for every criterion of each sustainability dimension); a visualisation of these improvements by means of a radar diagram; and a visualisation of the interactions that illustrate improvements.

Key questions:

- What are the potential environmental, socioethical and economic improvements that the system concept can generate?

- Does the system concept have any critical points from an environmental, socioethical and/or economic point of view? Do any of its elements need redesigning?

System Design and Engineering

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

The processes connected to this stage are described below.

Detailed system design (executive level)

The aim of this activity is to develop the system concept in detail, defining: the set of products and services that make up the offer; all the actors (both primary and secondary) involved in the system together with their roles; all the interactions between actors including the customer that occur during delivery of the offer; all the elements (both material and non-material) required for delivery of the offer and who will design/produce/deliver them.

Key questions:

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

Environmental, socioethical and economic assessment

The aim of this activity is to assess more accurately the environmental, socioethical and economic benefits that the system innovations will produce once implemented. The result will be a more detailed description of the potential improvements for each project (for every criterion of each sustainability dimension), a visualisation of these improvements by means of a radar diagram, and a visualisation of interactions that illustrate the improvements.

Key questions:

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

Communication

The communication stage aims to communicate the general characteristics of the solution designed, and above all those regarding sustainability, to the outside world.

The basic aim is to provide a document indicating:

- The general characteristics of the product-service system. The elements that make up the system innovation are described: the set of products and services that the offer consists of; the primary and secondary actors involved in the system and their respective roles and interactions; and the interactions between the actors and customer

- The sustainability characteristics of the product-service system. The potential improvements (from an environmental, socioethical and economic point of view) to be gained from the implementation of the solution are shown, with an indication of the elements of the system that will deliver these improvements.

7.2 SD4SEA Tools

The method includes not only a series of existing or adapted tools but also new tools designed, implemented and tested specifically to design S.PSS applied to DRE. These tools are listed below and will be described in this chapter:

- Sustainability Design Orienting Scenario on S.PSS&DRE;
- Strategic Analysis SA template;
- Sustainable Energy for All Idea Tables and Cards;
- E.DRE—estimator for distributed renewable energy;
- S.PSS + DRE Innovation Map;
- S.PSS + DRE Design Framework and Cards;
- Energy System Map;
- Innovation Diagram for S.PSS&DRE;
- Concept Description Form for S.PSS&DRE.

The description of the other following tools for S.PSS design could be found in the tool section of www.lenses.polimi.it:

- Satisfaction System Map;
- SDO toolkit;
- Interaction table (and storyboard);
- Offering Diagram.

The design tools will be described according to their aims, what they consist of, how to use them, integration in the design process, their results, their availability and required resources.

7.2.1 *Sustainability Design Orienting Scenario (SDOS) on S.PSS&DRE*

Aims

Design Orienting Scenario [11], a tool to inspire and inform designers towards possible futures on specific topics, has been adapted [1, 12] to Sustainable Product-Service System (S.PSS) applied to Distributed Renewable Energy (DRE). The tool, (from now on) Scenario presents four visions narrated as interactive

videos accessible through a navigator file. The Scenario is a tool to inspire designers and stakeholders to design radically new social, economic and technical solutions and as co-design strategic conversations and facilitating creative processes among different actors (Fig. 7.1).

What it consists of

The tool allows to watch the videos to inspire towards Sustainable Product-Service System (S.PSS) applied to Distributed Renewable Energy (DRE) solutions. The tool presents four visions within a polarity diagram of two axes. The horizontal axis defines who is the customer of the narration final user (B2C), or as small entrepreneur/small business (B2B). The vertical one defines the offer: a Distributed Renewable Energy generator (e.g. solar panel system plus its appliances such as storage, inverter, wires, etc.), or the sum of both the Distributed Renewable Energy generator and the related Energy-Using Products or Energy-Using Equipment (e.g. phone and television are Energy-Using Products; woodworking machine, sewing machine are Energy-Using Equipment). Each vision is presented through one short video (around 90 s) that shows peculiar narration, highlighting the key points of the vision (e.g. stakeholder interactions, ownership. Three sub-videos (around 30 s each) help to achieve the understanding of a wider range of opportunities than presented in the video of the vision; these three sub-video show: (1) all the possible offer and the related payment modality; (2) all the possible stakeholders that can be involved and their possible interactions; (3) all possible sustainability benefits (environmental, socioethical and economic).

How to use the tool

The Scenario requires the use of a slideshow software (e.g. Open Office PowerPoint). Each video and sub-video can be watched separately or a central button is available to run the whole videos as one. The suggestion is to watch a main video first and after the related sub-videos, then, the second main video and so on.

Integrating the tool into the design process

The Scenario can be used during the *Exploring Opportunities*.

Exploring opportunities

It can be used to inspire and inform designers and actors involved towards possible visions of Sustainable Product-Service System (S.PSS) applied to Distributed Renewable Energy (DRE), and to get new inspirations during the process.

Results

The result is a set of ideas favouring creative processes and co-design activities towards concepts of Sustainable Product-Service System (S.PSS) applied to Distributed Renewable Energy (DRE).

Tool availability and required resources

The tool is available for free download at www.lenses.polimi.it. The tool has been designed to be used in workshops and co-design sessions, therefore a projector is preferable. The time required to visualise all videos is approximately 15 min.

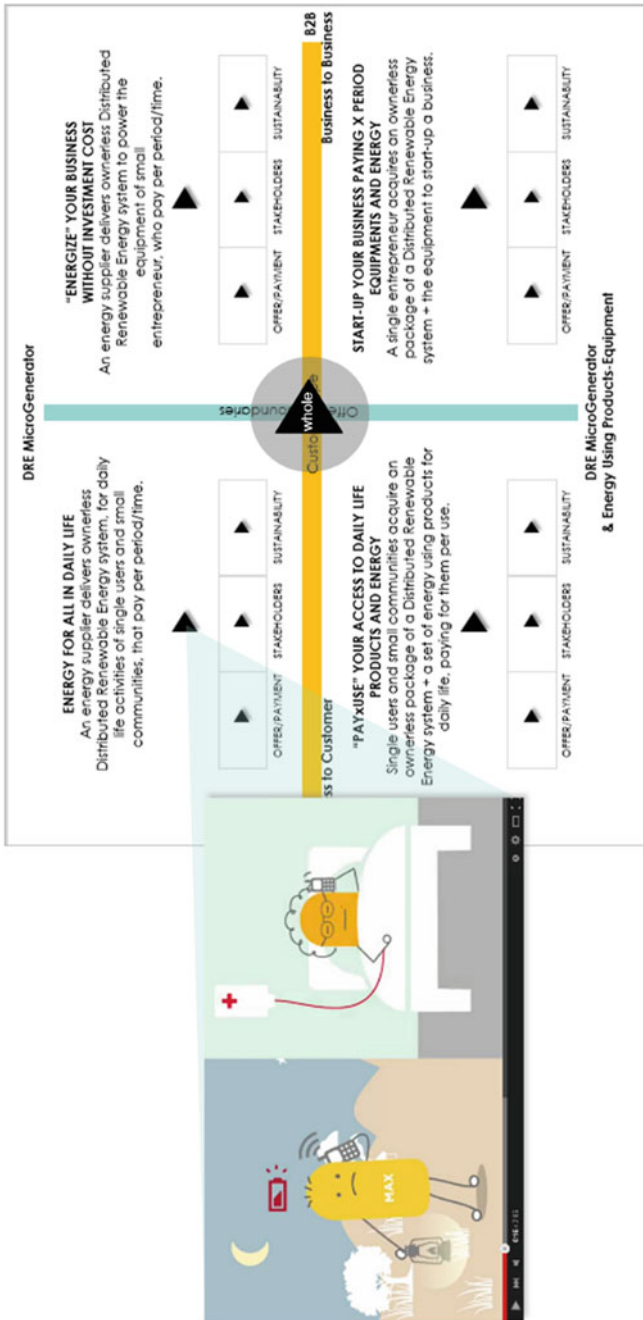


Fig. 7.1 Sustainability design orienting scenario on S.PSS and DRE. Source designed by the Authors

7.2.2 Strategic Analysis (SA) Template

Aims

Strategic Analysis (SA) template, a tool to collect and process the background information necessary to the generation of a set of potentially sustainable solutions. On the one hand, it aims to understand the existing situation and find out more about the existing proposers, the socio-economic context in which they operate and the dynamics (socio-economic, technological and cultural macro-trends) that influence that context; on the other hand, it aims to process information by which to steer the designing process towards the generation of promising sustainable solutions (Fig. 7.2).

What it consists of

The tool is an editable template based on five sections:

- A. Design brief;
- B. The context;
- C. Existing system;
- D. Qualitative sustainability evaluation of existing system;
- E. Access to energy.

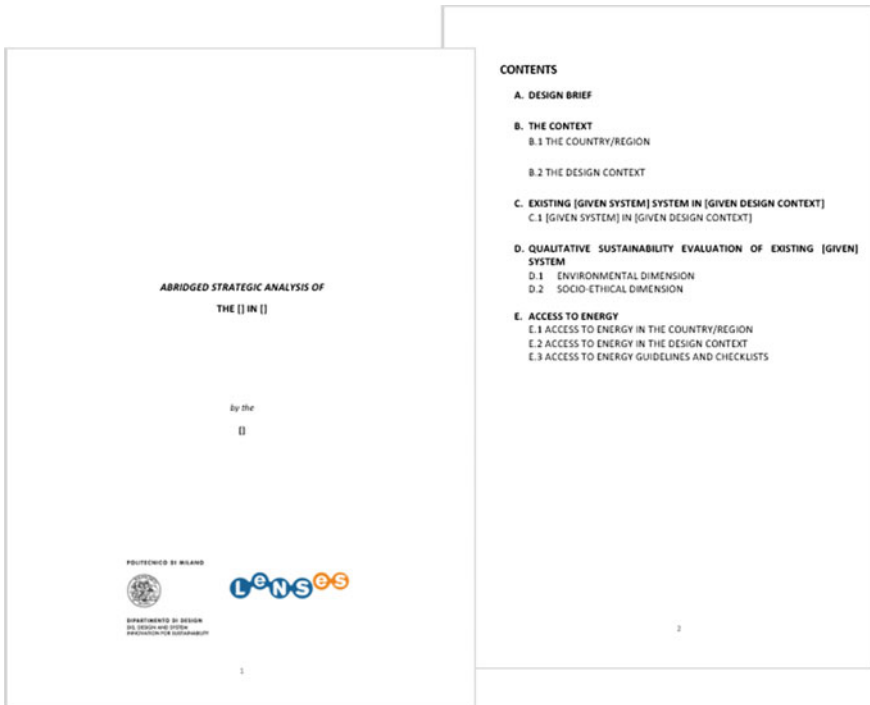


Fig. 7.2 Strategic analysis (SA) template. Source designed by the Authors

For each section, a set of subsections with questions and/or guideline is available to support its completion.

How to use the tool

The Strategic Analysis (SA) template can be printed or edited in its digital version. Each section and sub-section can be filled separately and according to the aim of the activity.

Integrating the tool into the design process

The Strategic Analysis (SA) template can be used during the *Strategic Analysis*, aiming to collect preliminary information and (if needed) setting the bases for the design activity.

Results

The result is a collection of information about design brief, context and the related access to energy, existing system as well as its sustainability (environmental socioethical, economic).

Tool availability and required resources

The tool is available for a free download at www.lenses.polimi.it. To be used in its digital version, an editing software is needed (e.g. Open Office Word). The time required could last from hours to days, according to the detail of the information.

7.2.3 Sustainable Energy for All Idea Tables and Cards

Aims

Sustainable Energy for All Idea Tables [13], structured on the SDO toolkit,¹ it is a tool to generate ideas for S.PSS applied to DRE solutions, it is based on six idea tables with guidelines. To the guidelines of each table are connected 15 case studies to be used as examples. For each of the case study, a card has been developed. The Sustainable Energy for All Idea Tables is presented as a co-design tool to generate (sustainable) ideas facilitating the creation process (Figs. 7.3, 7.4 and 7.5).

What it consists of

The tool allows the generation of (sustainable) ideas for S.PSS applied to DRE solutions. Six idea tables with criteria and guidelines are available to orientate the design process. Fifteen case studies and cards can be used as supportive examples associated to the guidelines.

Each table refers to a *criterion* (and includes specific guidelines) to design (sustainable) ideas for an S.PSS applied to DRE concept. The criteria are the following and they are described with their guidelines in Chap. 5:

¹The SDO Toolikt has been adapted to the new criteria and guidelines for sustainable energy for All. The SDO toolkit was developed by Carlo Vezzoli and Ursula Tischner within the MEPSS EU 5th FP, Growth project.

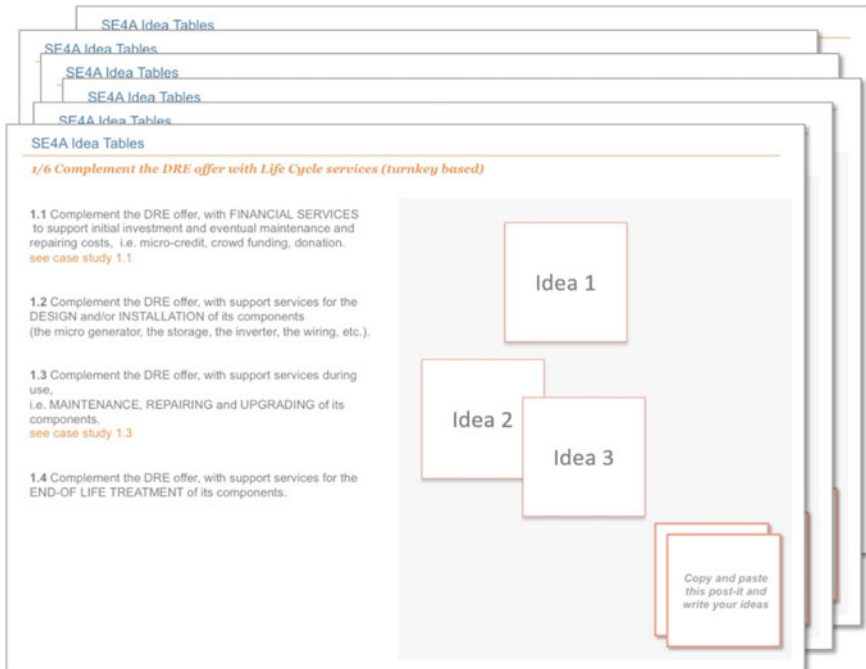


Fig. 7.3 Printable sustainable energy for all idea tables. *Source* designed by the Authors

1. Complement the DRE offer with Life Cycle services (turnkey based);
2. Offer ownerless DRE systems as enabling platform;
3. Offer ownerless DRE systems with full services;
4. Add to DRE offer, the supply of ownerless Energy Using;
5. Delinked payment from pure watt consumption (affordable costs);
6. Optimise DRE systems configuration.

How to use the tool

The Sustainable Energy for All Idea Tables tool could be used with two modalities.

- a slideshow software (e.g. Microsoft PowerPoint, or the equivalent in Open Office) or, in the case it is printed, it will require post-it and pens;
- the SDO toolkit software in the dimension of *Sustainable Energy for All*.

Use of the idea tables

Each table needs to be used singularly and presents a series of guidelines which are suggestions to orient the design of (sustainable) ideas in relation to a specific offer. Aside from the guidelines, an empty space is left to post ideas. After reading the guidelines, it is possible to use the post-it (digital or in paper) to write ideas. As general rules: no ideas are wrong; there is not a compulsory number of ideas to be written; the ideas need to be at system-stakeholders' interaction level and not at product level, e.g. offer the use of a bike (sharing) with a payment based on time of use to bring kids to school, but not a bike itself.

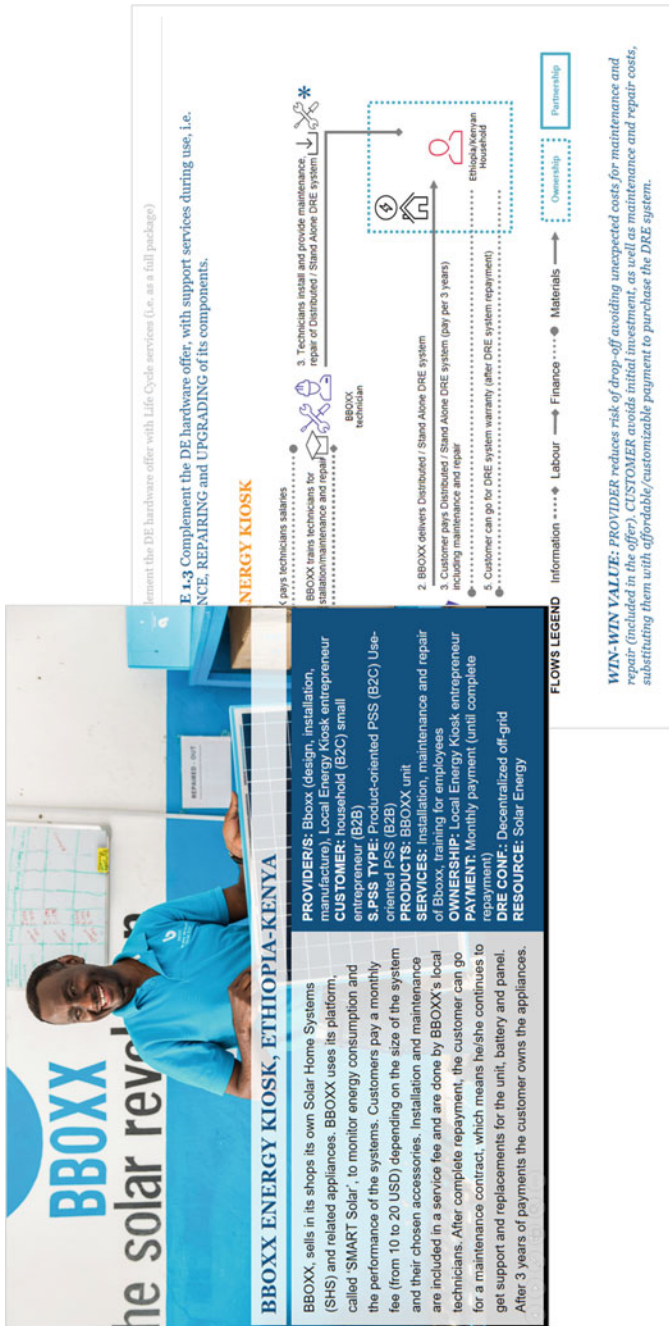


Fig. 7.4 Cards (with case studies) to complement the sustainable energy for all idea tables. Source designed by the Authors

Menu
 Save
 Reload
 Print
 Logout
 Help

Energy Sustainability - Orientate Concept

Optimise DRE systems configuration

Complement the DRE offer with life cycle services

System

Offer ownerless DRE systems with full services

Service

Offer ownerless DRE systems as enabling platform

Example

Add to DRE offer, the supply of ownerless energy using products

IDEA 1

Complement the DRE offer with life cycle services

priority:

Complement the DRE offer, with (turnkey based) support services for the DESIGN and/or INSTALLATION of its components (the generator, the storage, the inverter, the w

Complement the DRE offer, with (turnkey support services during use, i.e. MAINTENANCE, REPAIRING and UPGRADING of its components

Complement the DRE offer, with (turnkey support services for the END-OF LIFE TR of its components

Complement the DRE offer, with (turnkey support services for TRAINING/INFORM

IDEA 1

IDEA 1

DOMESTIC CHOOLES, ZIRAKPUR, INDIA

The company installed biogas plants in households, their users can be trained to provide biogas for cooking and lighting. The 9 m³ plant (used for one household) costs between 320 usd and 420 usd (21,200 and 27,200 INR). The plant is installed in the household and is owned by the user and paid monthly. The cost of the biogas plant includes a three-year guarantee period, during which maintenance and repair are provided by the installation company.

PROVIDERS: Subsidized factories
CUSTOMERS: Households (single use),
PRODUCTS: Biogas, cooking gas, products for sale
PROCESSES: Biogas plants
RESOURCES: Biogas plants
REVENUE: Biogas plants
MAINTENANCE: Biogas plants
REPAIRING: Biogas plants
UPGRADING: Biogas plants
TRAINING: Biogas plants
INFORMATION: Biogas plants
RESOURCES: Biogas plants

IDEA 1

Fig. 7.5 Digital version of sustainable energy for all idea tables and cards (with case studies). Source designed by the Authors

Use of the case study either as online access or as cards

Each case study represents an existing case of S.PSS applied to DRE in relation to a specific guideline. Each card is made of a short description with the key information: customer, provider, type of S.PSS, offered products (and related ownership), offered services (and related provider), what is paid, DRE source, DRE system configuration (front of the card) and a visualisation of the stakeholder's interactions through an Energy System Map,² where the interaction representing the guideline is highlighted.

Integrating the tool into the design process

The Sustainable Energy for All Idea Tables and examples are used in the *Exploring opportunities* stage to support the generation of (sustainable) ideas towards S.PSS applied to DRE solutions.

Results

The results are new sustainable ideas (written in the post-it) of Sustainable Product-Service System (S.PSS) applied to Distributed Renewable Energy (DRE). The most promising ideas are transferred into the Innovation Diagram for S.PSS&DRE to generate the concept (more about in paragraph 2.6.7, where the tool is presented).

Tool availability and required resources

The tool is available for a free download and in copy-left at www.lenses.polimi.it. The tool has been designed to be used in workshops sessions, therefore is good to work on it collectively, though it could be used even by one person only. It is available both with digital version which could be used through a pc with or without a projector (suggested if the group is composed by more than 3–4 person) or as printable one (suggested to be printed as A3–A2). The case study cards are available in digital and printable version, the suggestion is to print them to facilitate the exchanges between the group. The time required is approximately 60 min (10 for each idea table).

7.2.4 E.DRE—Estimator for Distributed Renewable Energy

Aims

The tool [13] is developed to support the design of Distributed Renewable Energy (DRE) systems, as well as to guide the evaluation of the energy demand and need of the designed system concept, and to assess the best system configuration and estimate the energy production potential (Fig. 7.6).

²Energy System Map tool has been developed in the LeNSes project (see paragraph 6.6).



Fig. 7.6 S.PSS and DRE estimator of DRE load/need and production potential. *Source* designed by the Authors

What it consists of

The tool is composed of six main worksheets (in one excel file):

1. Worksheet for *energy load/need* and *energy production potential*, it summarises the energy load/need to satisfy the system appliances, and compares such data with the table that summarise the energy production potential of the DRE 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 Renewable Energy (DRE) resource*, which allows to calculate the energy/gas production potential for a specific context, through the support of online databases and websites. The worksheets available are the following: worksheet for photovoltaic system sizing; worksheet for wind system sizing; worksheet for hydro system sizing; worksheet for biomass digester sizing.

The tool integrates databases and websites to get data on the local availability of renewable resources (e.g. Geographical Assessment of Solar Resource irradiation) (Figs. 7.7, 7.8, 7.9 and 7.10).

How to use the tool

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 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 DRE system designed (if any) to verify correspondence of energy need and energy availability. A second step is to size (or resize in case of existing) the DRE system according to the energy need to be satisfied. To do this, first step is to define the local renewable energy resource to be used: sun, wind, water and biomass (worksheets 3–4–5–6), and then to dimension 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.

Integrating the tool into the design process

The E.DRE tool is used in the *Design System Concept* stage to draft the new DRE systems, according to energy need and locally available resources.

Results

The result from the E.DRE tools is a preliminary sizing of new DRE systems, according to energy need and locally available resources.

Tool availability and required resources

The tool is available for a free download at www.lenses.polimi.it. It is available in digital version which could be used through a pc or a projector and requires internet connection to reach information from the online databases. The time required is approximately 60 min.

PHOTOVOLTAIC ENERGY SYSTEM SIZING

MONTHLY GLOBAL SOLAR IRRADIATION
how to get the minimum solar irradiation value

H= ANNUAL IRRADIATION kWh/m²/year

ηPV= PV modules efficiency (select below)

select PV modules type

Average of system losses

ηBO.S (Balance of System efficiency)
(ask the beside to calculate: b51505)

Inclination

Orientation
(Azimuth angle: from -180 to 180, East=-90, South=0)

nBOS: Losses details
(depend of site, technology, and sizing of the system)

Inverter losses (6% to 15%)	8%
Temperature losses (5% to 15%)	8%
DC cables losses (1 to 3%)	2%
AC cables losses (1 to 3%)	2%
Shadings (0% to 40%; depends of site)	3%
Losses weak irradiation 3% or 7%	3%
Losses due to dust, snow... (2%)	2%
Other Losses	0%

RETURN BACK

Global formula: $E = S \cdot \eta(PV) \cdot H \cdot \eta(BO.S)$

Legend

Enter your own data

Result (do not change the value)

Calculated value (do not change the value)

STARTING FROM YOUR ENERGY LOAD/NEED

E= ENERGY NEED kWh/year

N= NOMINAL POWER kWp

S= SURFACE NEEDED m²

AVERAGE COST OF THE SYSTEM \$

more information about cost: [base](#)

Is your system off-grid?

INVERTER SIZE (W) AC+DC loads

ENERGY DAILY USAGE (kWh)

DAYS OF AUTONOMY (suggested from 2 to 5 days)

SYSTEM VOLTAGE

Small daily loads < 1kW = 12V

Intermediate daily loads < 3-4 kW = 24V

Larger loads > 4 kW = 48V

MAXIMUM DEPTH OF DISCHARGE (60%)

TOTAL BATTERY CAPACITY NEED (Ah)

BATTERY BANK CAPACITY (Ah)

NUMBERS OF BATTERIES

BATTERY TYPE

AVERAGE COST OF THE BATTERY (\$)

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

S= AVAILABLE SURFACE m²

N= NOMINAL POWER kWp

E = ESTIMATED ENERGY PRODUCTION kWh/year

AVERAGE COST OF THE SYSTEM \$

more information about cost: [base](#)

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

B = BUDGET \$

N= NOMINAL POWER kWp

E = ESTIMATED ENERGY PRODUCTION kWh/year

S= SURFACE NEEDED m²

more information about cost: [base](#)

START

ENERGY NEED-PRODUCTION

EUP POWER CONSUMPTION DATABASE

WIND SYSTEM SIZING

PV SYSTEM SIZING

HYDRO SYSTEM SIZING

Fig. 7.7 Worksheet—solar energy. Source designed by the Authors

WIND SYSTEM SIZING

RETURN BACK

Site	1,20
ρ = AIR DENSITY	kg/m ³
v = MINIMUM WIND SPEED	m/s
<i>base</i> how to get the wind speed value	
POWER COEFFICIENT Cp	0,4
<i>(between 0,2 and 0,6) the maximum power that can be extracted from the wind according to Betz is 59,3 %</i>	

STARTING FROM YOUR ENERGY LOAD/NEED

E-ENERGY NEED	kWh/year	0,00
POWER WIND (per turbine)	kW	#DIV/0!
POWER TURBINE (per turbine)	kW	#DIV/0!
BLADE LENGTH	m	#DIV/0!
<i>(3m max radius suggested per turbine)</i>		
SWEEP AREA (per turbine)	m ²	#DIV/0!
TURBINE HEIGHT (at least)	m	#DIV/0!
NUMBER OF TURBINE	n	#DIV/0!
ENERGY ESTIMATED PRODUCTION PER TURBINE	kWh/year	#DIV/0!
AVERAGE COST OF THE SYSTEM	l	0,00

STARTING FROM BLADE LENGTH

BLADE LENGTH	m	
<i>(3m max radius suggested per turbine)</i>		
SWEEP AREA	m ²	0,0000
TURBINE HEIGHT (at least)	m	0,0000
POWER WIND	kW	0,00
POWER TURBINE	kW	0,00
ENERGY ESTIMATED PRODUCTION PER TURBINE	kWh/year	0,00
NUMBER OF TURBINES	n	
TOTAL ENERGY ESTIMATED PRODUCTION PER WIND SYSTEM	kWh/year	0,000

Classification of wind resource by wind speed range

Class	Wind Speed	mph
Marginal	4 to 5	9 to 11,3
Fair	5 to 6	11,3 to 13,5
Good	6 to 7	13,5 to 15,8
Excellent	7 to 8	15,8 to 18
Outstanding	over 8	Over 18

Global formula: $E = C_p \cdot \rho \cdot A \cdot v^3 \cdot h$

Legend

Enter your own data	
Result (do not change the value)	
Calculated value (do not change the value)	

SWEPT AREA

The swept area refers to the area of the circle created by the blades as they sweep through the air.

Is your system off-grid?

INVERTER SIZE (W) AC+DC loads	0,0
DAILY ENERGY LOAD (Wh)	0,00

DAYS OF AUTONOMY
(suggested from 2 to 5 days)

SYSTEM VOLTAGE

Small daily loads < 1kW = 12V
Intermediate daily loads < 3-4 kW = 24V
Larger loads > 4 kW = 48V

MAXIMUM DEPTH OF DISCHARGE (60%)

TOTAL BATTERY CAPACITY NEED (Ah) #DIV/0!

BATTERY BANK CAPACITY
(Ah)

NUMBERS OF BATTERIES #DIV/0!

WIND SYSTEM SIZING

HYDRO SYSTEM SIZING

BIOGAS DIGESTER SIZING

Fig. 7.8 Worksheet—wind energy. Source designed by the Authors

HYDRO ENERGY SYSTEM SIZING

Site	300
Q = Water flow rate	Stream
	l/s
g = Gravity	9.81
	m/s ²
η = Efficiency	0.5

STARTING FROM YOUR ENERGY LOAD/NEED

ENERGY NEED	0,000
HYDROPOWER	kW
E = GENERATOR POWER	0,0000
H = HEAD	0,000
AVERAGE COST OF THE SYSTEM	0,00

Do you have a head different from the one calculated?

HEAD	0,000
HYDROPOWER	kW
E = GENERATOR POWER	0,000
ENERGY ESTIMATED PRODUCTION	0,000
AVERAGE COST OF THE SYSTEM	0,00

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

BUDGET	0,000
HYDROPOWER	kW
E = GENERATOR POWER	0,000
HEAD	0,000
ENERGY ESTIMATED PRODUCTION	0,000

[RETURN BACK](#)

Global formula E= H*Q*ρ*g*η*h
Legend

Enter your own data	
Result (do not change the value)	
Calculated value (do not change the value)	


FLOW RATE AVERAGE

click here to see some examples of river flow

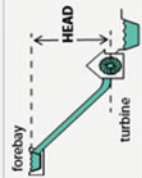
Very small stream	10-50
Small stream	50-250
Stream	250-1000
Small river	1000-2000
River	2000

FLOW MEASUREMENT


Using a bucket and a stopwatch. The volume of the container is known and the flow rate is simply obtained by dividing this volume by the filling time.





Volume of the container (water)	l
Filling time	s
Water flow	l/s
	0





Head is the vertical distance the water falls. Higher heads require less water to produce a given amount of power.











... | EUP POWER CONSUMPTION DATABASE

PV SYSTEM SIZING

WIND SYSTEM SIZING

HYDRO SYSTEM SIZING

BIOGAS DIGESTER SIZING

Fig. 7.9 Worksheet—hydro energy. Source designed by the Authors

BIOGAS DIGESTER SIZING

RETURN BACK

Define your feedstock availability

V= TOTAL DAILY FEEDSTOCK (t) **0,0072**

Gy= TOTAL BIOGAS YIELD (m³/day) **0,252**

ANIMAL	N° of animals	daily manure (t/day)	VS% of VS	t/VS (t/day)	Biogas yield (m ³ /h)	Total biogas yield	
Cattle (650 kg)		0,055	0	80	0	19	
Dairy cattle		0,055	0	80	0	25	
Pig	2	0,0045	0,009	80	0,007	28	
Sheep		0,002	0	75	0	20	
Horse		0,02	0	80	0	63	
Chicken		0,0002	0	75	0	140	
ENERGY CROPS	Area (ha)	Yield (t/ha)	Amount of crops (t/d)	VS%	t/VS	Biogas yield (m³/h)	Total biogas yield
Grass silage		0,5	0	90	0	160	0
Triticale		0,3	0	93	0	337	0

STARTING FROM FEEDSTOCK AVAILABILITY

Vd= DIGESTER VOLUME m³ **0**

G= DAILY GAS PRODUCTION m³/day **0,00**

Pr= Retention time days **30**

Sd= Daily substrate input t **0,0144**

water m³/d **0,0072**

AVERAGE COST OF THE SYSTEM | 0,27

Biogas potential comparison

1 m³ of biogas	0.61l of diesel (fuel)
	5.5Kg of firewood

Legend

Enter your own data

Result (do not change the value)

Calculated value (do not change the value)

Global formula: G= Vd*Gy
Vd= Sd*Pr

...
EUP POWER CONSUMPTION DATABASE
PV SYSTEM SIZING
WIND SYSTEM SIZING
HYDRO SYSTEM SIZING
BIOGAS DIGESTER SIZING

Fig. 7.10 Worksheet—biomass energy. Source designed by the Authors

7.2.5 PSS + DRE Innovation Map

Aims

The tool [5–7] can be used for classifying S.PSS models applied to DRE, positioning company's offers, analysing competitors in the market and exploring new opportunities. The tool can be also used for generating new concepts of S.PSS applied to DRE.

What it consists of

The tool is composed of the *Innovation Map*, the *Archetypal Models Cards*, *Stakeholder Cards* and a set of *Concept Cards*. The Innovation Map has been built as a classification system for S.PSS and DRE models [2] (see Sect. 4.4). The tool was built as a polarity diagram that combines different types of S.PSS models with the DRE energy systems and it can be used to position companies and new concepts according to the type of business model and the technology involved.

The vertical axis distinguishes the different types of S.PSS models, i.e. what is being offered to customers and what do they pay for. The different S.PSSs types on the Innovation Map help users to classify energy solutions based on what is the focus of the offer (product, use or result-oriented) and what is the payment structure (e.g. pay-to-purchase a product with financing services, pay-to-rent or pay-per-energy consumed). The vertical axis also encompasses ownership structure and environmental sustainability potential.

On the horizontal axis, the different types of DRE systems are illustrated: *mini kit*, *individual energy system*, *charging station*, *isolated mini-grid* and *connected mini-grid*. The horizontal axis encompasses also the type of target customers addressed in the S.PSS solution. It ranges from individual target (including the individual use of energy for households, entrepreneurs, productive activities, community buildings), to community target (which includes altogether a number of households, and/or productive activities, community buildings, public spaces, etc.) (Fig. 7.11).

The Archetypal Models Cards collect different types of S.PSS applied to DRE with corresponding case studies and a system map that illustrates how the system work (see Sect. 4.4) (Fig. 7.12).

The Stakeholders Cards aim at detailing actors and competitors involved in the energy scenario and at understanding their roles and responsibilities. This type of card can be used during the strategic analysis of competitors (see next section) (Fig. 7.13).

The concept Card aims at providing a template for generating new concept directions of S.PSS applied to DRE and it includes type of offer, network of providers, products, services, customers and payment channels. It can be used during the idea generation session (see next section) (Fig. 7.14).

How to use the tool

The tool can be flexibly used in different stages on the design process, from the strategic analysis (e.g. positioning company's offers and its competitors) to the idea generation and concept development phase.

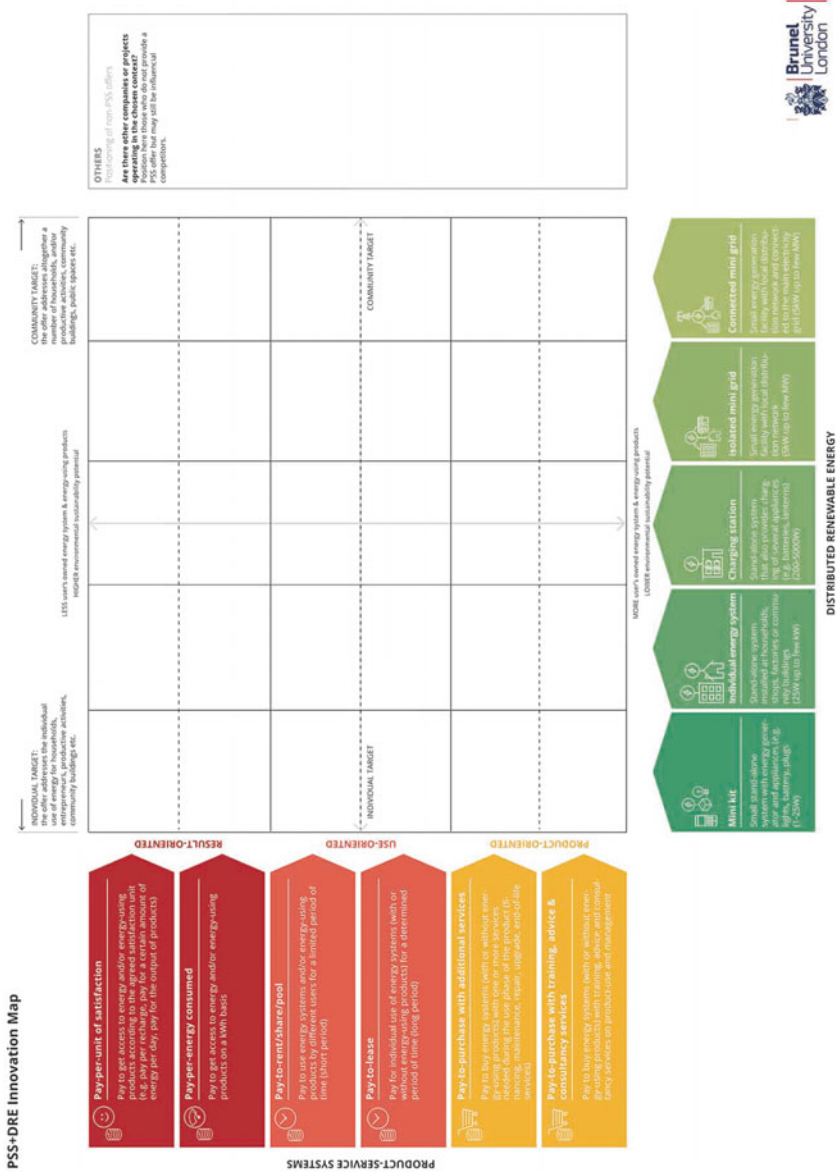


Fig. 7.11 PSS + DRE innovation map. Source Emili [7]



Fig. 7.12 Archetypes cards. Source [7]

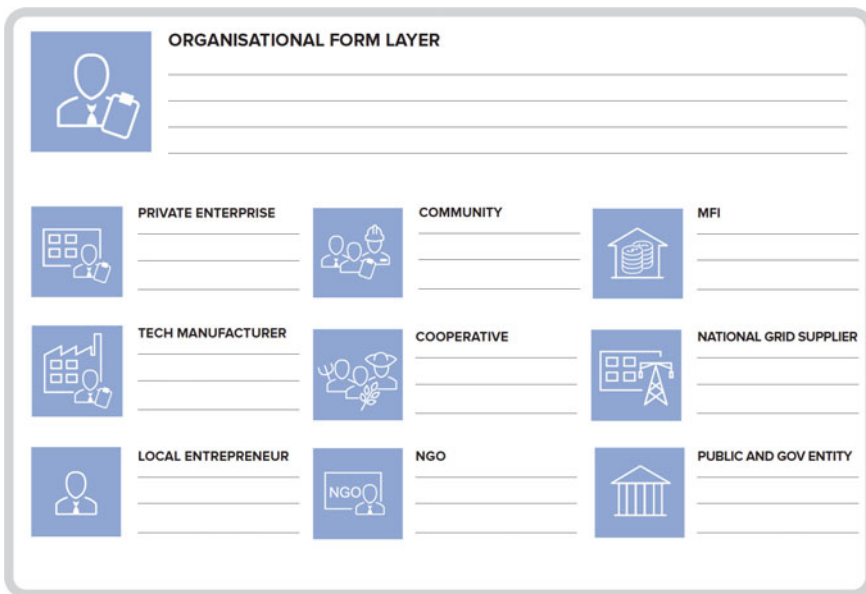


Fig. 7.13 Stakeholders card. Source Emili [7]

Fig. 7.14 Concept card. *Source* Emili [7]

Integrating the tool into the design process

The Innovation Map can be used for different purposes in the *Strategic analysis* and *Exploring opportunities* stages.

Strategic analysis

Position company’s offerings on the map

The tool can be used to position a company’s offerings according to the value proposition, type of energy system and target customer. Users can write down the company’s offering on post-its (one offering per post-it), and place them on the map. The positioning should follow the type of S.PSS, i.e. product, use or result-oriented according to the specific payment structure and ownership model, and the type of DRE system involved in the solution. It should be highlighted that one company may have multiple offerings, and therefore these can be positioned on various parts of the Map (see Fig.3.1) (Fig. 7.15).

Map the competitors

Following the same criteria, companies operating in the selected context can be positioned on the Innovation Map, possibly using another colour of post-its. Users may want to focus on a specific technology (e.g. only mini-grid) or map all actors operating in a specific geographic area. If necessary, other offers that are not Product-Service Systems can be positioned in the box on the right-hand side of the Innovation Map (*Non-PSS offers*). These can include for example sale-based offers (e.g. sale of solar lanterns) or other complementary energy products (e.g. bioethanol fuel) (Fig. 7.16).

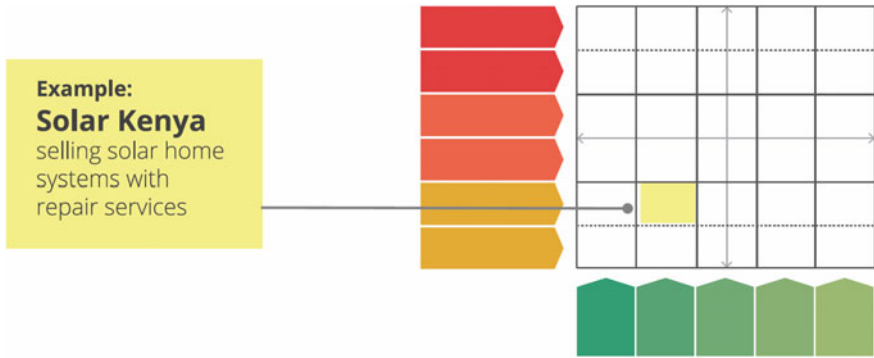


Fig. 7.15 Positioning of company’s offerings on the innovation map. *Source* designed by the Authors

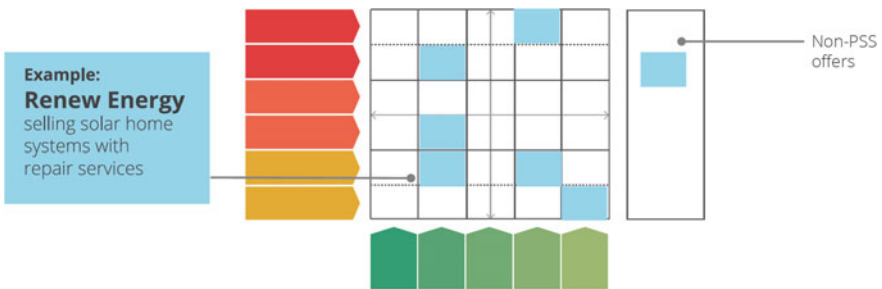


Fig. 7.16 Positioning of competitors on the innovation map. *Source* designed by the Authors

Strategic analysis of competitors: organisational form layer

To gather a deep understanding of the energy scenario, the tool can be used to detail the stakeholders that are providing energy solutions in a selected context and what roles and responsibilities they have. This phase aims at going more in-depth in analysing the target market by detailing the previously mapped solutions. The Stakeholder Cards can be used to define the actors involved and the roles they have. This phase can help users in understanding the main socio-economic actors operating in the energy sector in a specific area (Fig. 7.17).

Exploring opportunities

Select a promising area to explore

Having detailed the existing energy situation for the chosen context, users can focus on identifying promising areas to explore. This can be carried out by circling an area they want to focus on (Fig. 4.3). It could be a specific technology (e.g. individual energy systems) or a type of offering, or both. Areas that have not been explored by competitors in the same context may be a good starting point for tapping promising markets. It must be highlighted that the tool does not provide indications on how to identify promising areas. Instead, it acts as a framework to trigger and stimulate discussion among the design team (Fig. 7.18).

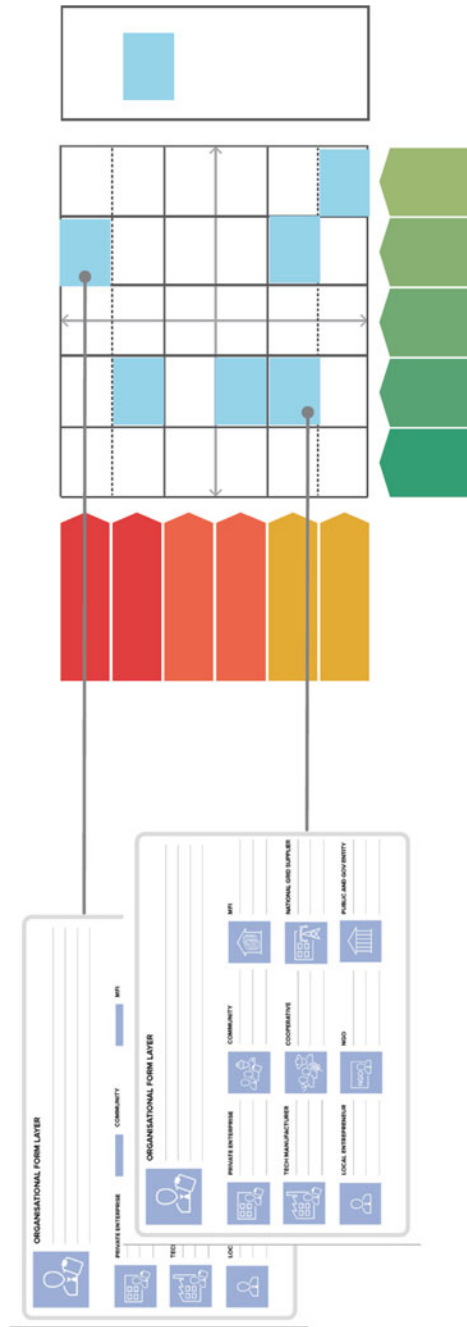


Fig. 7.17 Example of a completed stakeholder card. Source designed by the Authors

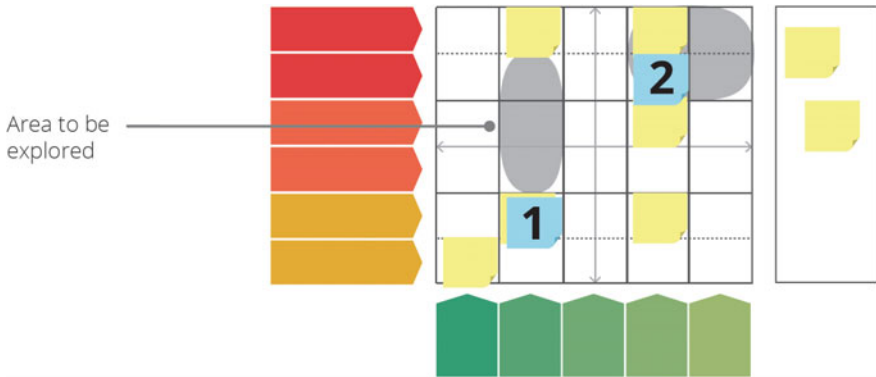


Fig. 7.18 Selection of promising areas to explore. *Source* designed by the Authors

Develop new concept directions

The Innovation Map can also support the design of new concepts of S.PSS applied to DRE. For this purpose, the Concept Cards can be used to write down ideas, starting by describing the general type of offer users intend to provide. Then, the corresponding number of the Concept Card can be positioned on the Map, following the same criteria used to map companies’ offerings. At this stage, it is advised to generate several concepts, they will be selected and refined in the second moment.

Then, for each concept, the card should be filled out by writing down ideas on customers, products and services, stakeholders and payment modalities. At this stage, the aim is to consider the several elements of the design solution, without necessarily going into detail (Fig. 7.19).

Select the most promising concept(s)

Once the phases of strategic analysis and concept generation are completed, the Innovation Map should provide a visualisation of existing businesses/competitors, stakeholders involved, promising areas to explore and new business concepts. This

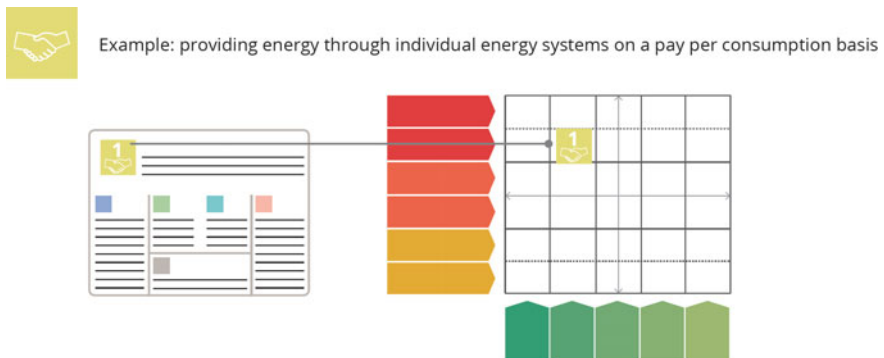


Fig. 7.19 Example of a completed concept card. *Source* designed by the Authors

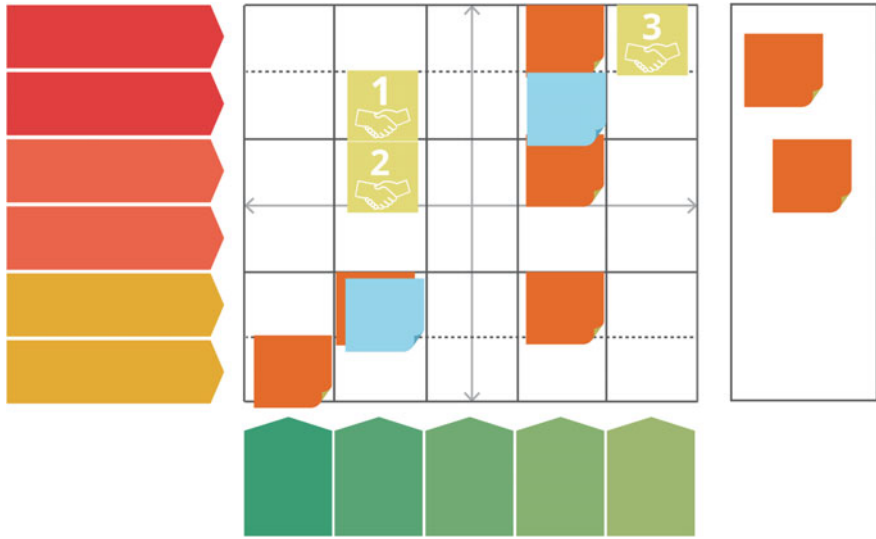


Fig. 7.20 Example of a completed innovation map. *Source* designed by the Authors

can be the starting point for a discussion within the company’s management team about which concepts are more promising, what influencing factors need to be considered and to eventually select one or more options for further detailing.

Results

At the end of the process, the Innovation Map provides a picture of the current situation (position of company’s offerings, competitors and stakeholders involved) and a selection of promising areas to be explored. The Innovation Map also provides a first idea generation support to identify new business opportunities (Fig. 7.20).

Tool availability and required resources

The tool is available for a free download at www.lenses.polimi.it and on www.se4alldesigntoolkit.com. The tool has been designed to be used in workshops and (co)design sessions, therefore, it is preferable to print it in a large format (at least A1). The time required for using the Innovation Map can vary, but a minimum of 2 h is suggested to complete all design phases.

7.2.6 S.PSS + DRE Design Framework & Cards

Aims

The tool [3, 7, 8] can be used to support the generation of ideas on specific aspects of S.PSS applied to DRE (network of providers, customer, products and services, offer and payment channel), and to bring an initial concept idea to a detailed concept.

What it consists of

The tool is composed by a Design Framework, a set of Cards and a Design Canvas (Fig. 7.21).

The Design Framework

The Design Framework visualises the main elements characterising S.PSS applied DRE models, which are organised in six ‘building blocks’. Each building block includes specific elements to be considered in the design, as described below.

Network of providers It refers to the actors involved in providing the energy solutions and it includes private enterprise, technology manufacturer, community, local entrepreneur, Non-Governmental Organisation (NGO), Cooperative, Micro-Finance Institution (MFI), public and governmental entity and national grid supplier.

Products It refers to the combination of energy system/s (including renewable energy sources) and energy-using product/s. **Energy systems** include stand-alone systems (mini kit, individual energy system, charging station) and grid-based systems (isolated and connected mini-grid). Energy systems also included the types of **renewable energy sources** used for DRE: solar, hydropower, biomass, wind or hybrid sources (i.e. combination of different renewables). **Energy-using products** refer to the appliances that can be included in the offer in combination with the energy systems (i.e. generator). These might include lantern, lights and bulbs, battery, phone charger, radio, TV, fan, IT and computer devices, etc.

Services The service category includes consultancy services (training, financing) and services provided during or at the end of the product life cycle (installation, maintenance and repair, product upgrade, end-of-life services).

Offer This building block refers to the different types of S.PSS offer that can be applied to DRE models. Their classification is divided into product-oriented (pay-to-purchase with training, advice and consultancy services; pay-to-purchase with additional services), use-oriented (pay-to-lease; pay-to-rent/share/pool) and result-oriented S.PSSs (pay-per-energy consumed; pay-per-unit of satisfaction).

Customers It refers to the type of target customers addressed by the S.PSS solution and includes individual household, productive activity, local entrepreneur, public buildings, community, public and governmental entity, mix of target customers.

Payment channels This building block refers to the different ways customers pay for the energy solution. It includes cash, credit, mobile payments, scratch cards and energy credit codes, in-kind contribution, fee collection and remote monitoring as an activity supporting payment.

For each building block, the Framework provides a series of questions that should guide the user in the design process. For example, the network of providers building block presents the following questions: ‘Who are the actors involved in the provision of the energy solution? What are their roles and responsibilities? What partnerships can be established?’ (Fig. 7.22).

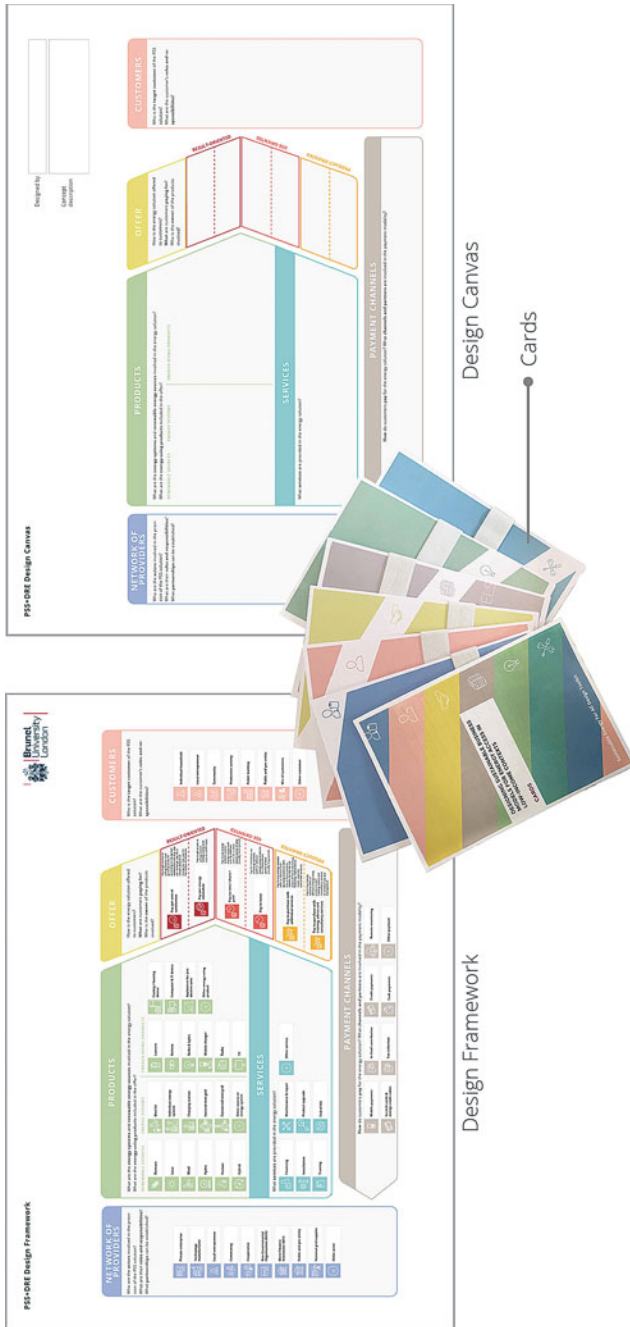


Fig. 7.21 The design framework, design canvas and cards. *Source* designed by the Authors

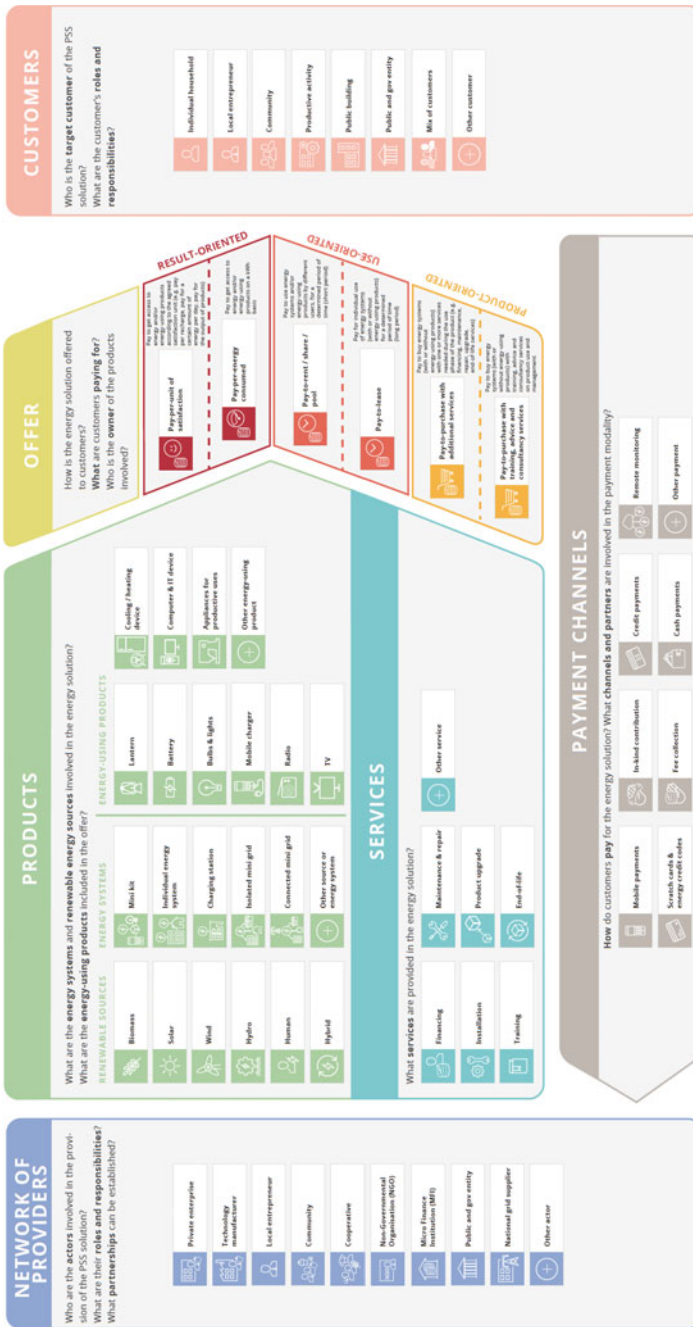


Fig. 7.22 Design framework. Source: Emili [7]

Cards

The Cards have been developed with the aim of providing support to companies and practitioners in designing the S.PSSs applied to DRE. In particular, they collect critical factors, guidelines and successful examples of S.PSS applied to DRE in low-income and middle-income contexts. In particular, the Cards summarise and organise in a clear and meaningful way the existing knowledge developed on S.PSS applied to DRE (i.e. critical factors and case studies [3], see Sect. 4.5), so that it can be used to trigger the generation of ideas. Cards are organised according to each building block (Fig. 7.23).

Each group of cards is provided with an Intro Card that specifies what information you can find in there and how to use it. A general structure of the elements contained in the cards is illustrated below (Fig. 7.24).

Design Canvas

The Design Canvas is an empty Framework that should be used in the concept generation phase to position post-its and write down ideas. The Canvas follows the same structure as the Design Framework and distinguishes S.PSS + DRE building blocks—network of providers, products, services, offer, customers, payment channels. It is also provided with some questions to guide the design process (Fig. 7.25).

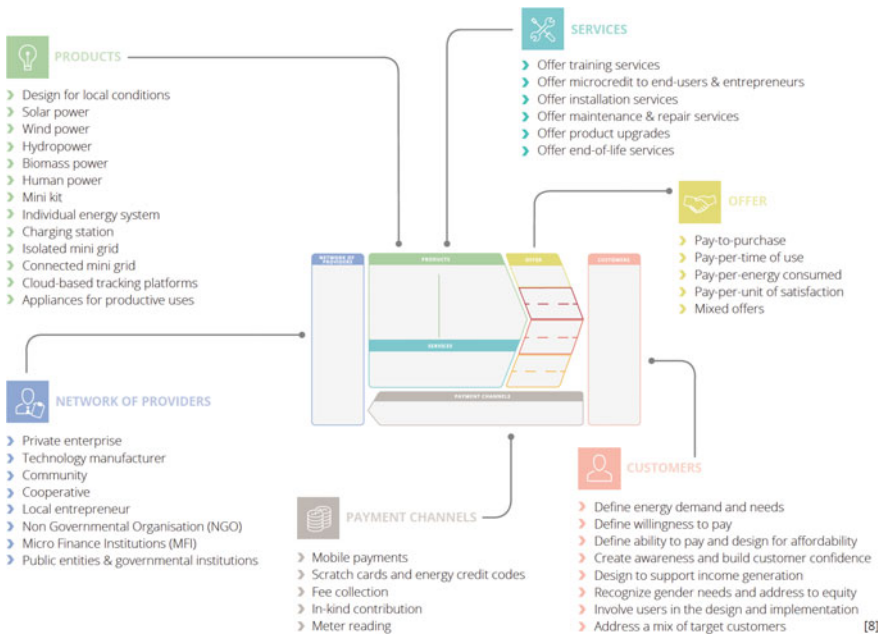


Fig. 7.23 List of cards for each design element. Source Emili [7]


SERVICES




Offer microcredit to end users and entrepreneurs

Offering microcredit solutions can allow providers to reach clients with lower or irregular incomes and to target local entrepreneurs who want to set up energy businesses.

- ▶ **Can you develop strategic partnerships with Micro Finance Institutions or other credit facilities?** Offering microcredit can be challenging if you don't have an existing customer base and a good knowledge of your target users *see also: Micro Finance Institution (MFI)*
- ▶ **Can you define willingness and ability to borrow?** Long term ability to pay, size of the down payment and monthly payments are influencing factors especially for customers with seasonal incomes (such as farmers). Pay attention to their credit history and the financing environment of customers *see also: define ability to pay and design for affordability*
- ▶ **Can you offer microcredit to entrepreneurs?** Helping them in covering capital costs to set up energy businesses (such as charging stations for renting of products).



South Asia



SEWA and SELCO

India

SEWA and SELCO: Self Employed Women's Association (SEWA) is an Indian cooperative bank that provides credit, counseling and insurance and it established a partnership with SELCO in order to support women empowerment. Together they design solar products and deliver comprehensive energy solutions, enabling lower income customers to get access to microcredit and clean power generation.

Photo: SELCO India

Fig. 7.24 Example of cards' structure. *Source* Emili [7]

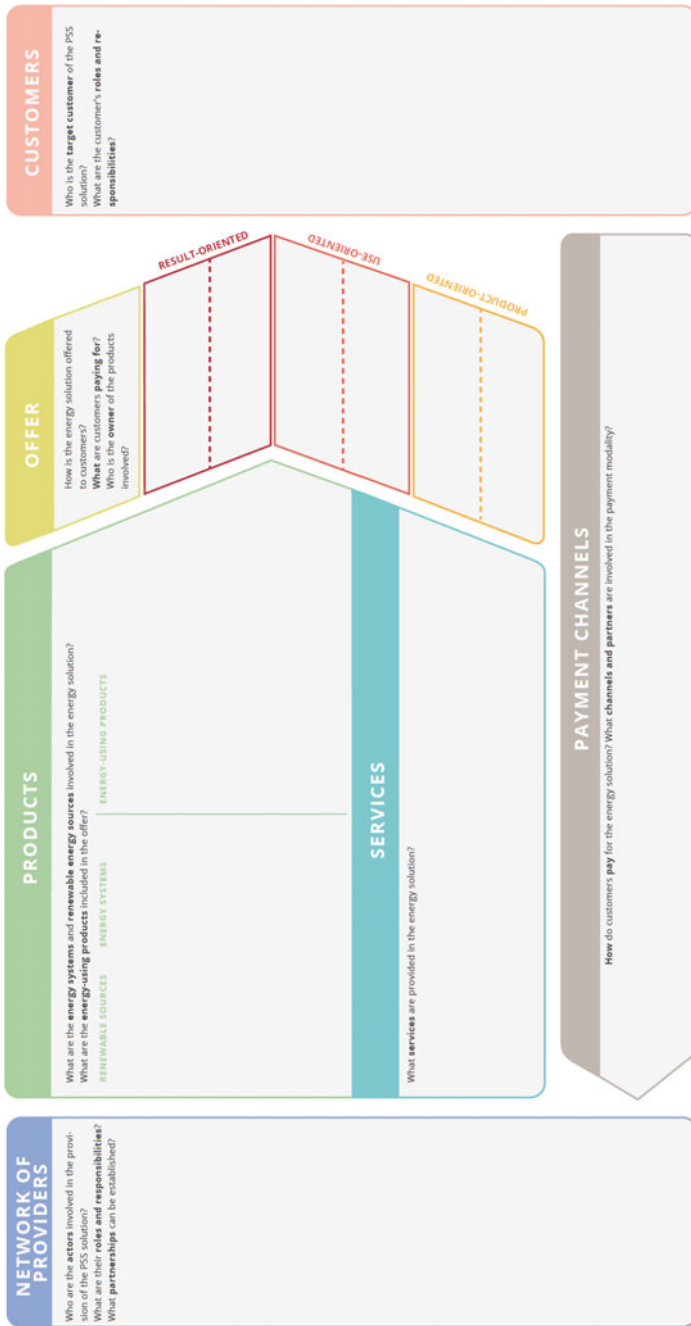


Fig. 7.25 The design canvas. Source Emili [7]

How to use the tool

The Design Framework and Cards has been developed to be flexibly applied according to users' needs. In particular, the tool finds application for:

- *start-up a new business*: to support the design and detailing of new business models from scratch.
- *refine and reorient existing solutions*: the tool can be used to focus on specific aspects of an existing business model. For example, a company might already have an offer in place but may want to improve aspects related to the payment channel.

This section illustrates how the Design Framework and Cards can be integrated in the SD4SEA design process and what outcomes can arise from its application.

Integrating the tool into the design process

Exploring opportunities

Generate ideas

The tool can be used in the beginning of the Exploring opportunities stage to support brainstorming sessions to generate ideas on the various building blocks of the Design Framework. In other words, the tool can be used when there is not any agreed concept direction, to inspire idea generation looking at the various aspects of S.PSS applied to DRE. Ideas then can be reviewed, selected and combined to develop initial concept directions. The idea generation process does not have to follow a specific order; it is possible to start from any building block.

System Concept Design

Detail initial concepts

The main application of the Design Framework and Cards is the detailing of an initial concept idea. In fact, the tool allows to go in-depth in all the building blocks and to generate ideas for each of them. This activity can be carried out after having used the Innovation Map to generate a concept idea, or if the designer/s has already a draft idea of the business model they would like to detail. After the idea generation, ideas are reviewed to select the most promising ones to be integrated into a detailed concept design.

Improve specific aspects of an existing solution

The tool can also be applied to brainstorm on a specific aspect of an existing S.PSS solution. For example, a company already delivering a S.PSS solution may want to improve the payment modality, and they can use the tool focusing only on the Payment Channels building block to get inspired by the guidelines, case studies and suggestions (Fig. 7.26).

The use of the tool does not require following a specific order for the idea generation. Users are encouraged to decide the starting point they prefer. The design process can be, therefore, carried out in an unstructured way, for example, browsing Cards and using the Framework as a reference, and then writing down ideas on post-its, positioning them on the Canvas (Fig. 4.11).

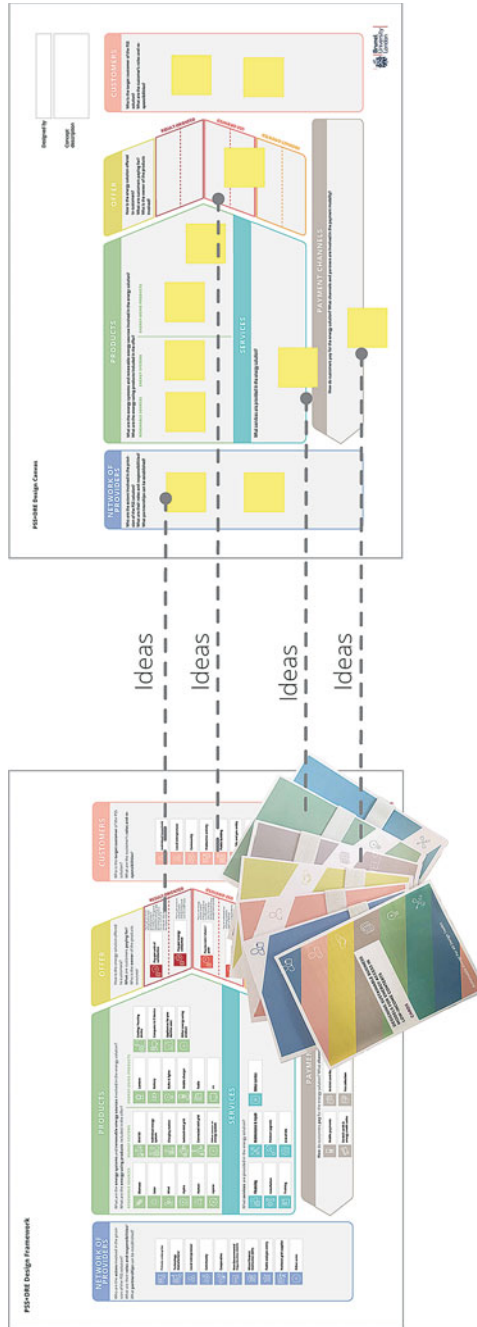


Fig. 7.26 Positioning ideas on the design canvas. Source designed by the Authors

Results

At the end of the design process, all elements of S.PSS applied to DRE should be detailed with selected ideas (among the ones generated in the activity), and the questions provided on the Canvas should be answered. The tool can be used in combination with other tools and resources; in fact, concepts generated with the tool might require further evaluation in terms of financial sustainability, technical feasibility, presence of appropriate regulations and other external factors.

Tool availability and required resources

The tool is available for a free download at www.lenses.polimi.it and on www.se4alldesigntoolkit.com. The tool has been designed to be used in workshops and (co)design sessions, therefore a printed format is preferable: the Design Framework should be at least A2, the Design Canvas can be printed in A1 and the Cards can be printed on A4 and folded.

To use the Design Framework and Cards, we suggest from a minimum of 2 h to grasp the most essential aspects; to a 8 h to go in-depth and detail every building blocks. We also suggest that the idea generation is carried out in multidisciplinary teams to maximise innovation potentials.

7.2.7 The Energy System Map

Aims

The Stakeholder System Map tool, developed by [7, 9] to visualise the network of stakeholders in a S.PSS solution, and their interactions (in terms of flows of goods, materials, services, money, work and information), has been adapted to be specifically used for S.PSS applied to DRE The Energy System Map [4] is presented as a visualisation tool, with its specific set of icons, flows and rules that aims at supporting (co)designing and visualisation of S.PSS applied to DRE models.

It is, therefore, a support tool for

- *Designing* because representation is a means of structuring thought and facilitating the resolution of problems;
- *Co-designing* because a standard language is used, which can, therefore, be shared by all the design team members or the different actors involved, supporting the strategic conversation among them;
- *Communicating* because it enables unambiguous visualisation of the designed solution (as well as its evolution).

What it consists of

The tool allows the development of a graphic representation showing

- the socio-economic actors involved in a S.PSS solution (both primary and secondary stakeholders);
- and the various interactions among these actors, in terms of flows of goods, materials, services, money, work and information.

The tool is a representational tool that can be described as both codified and progressive. It is a codified system in the sense that it can be considered a ‘technical drawing’ representing the actors involved in a S.PSS in a standardised and comparable way. It is progressive in the sense that it is a ‘formalisation-in-progress’ of the solution actor map giving an increasingly accurate picture of the project as it develops.

The tool is composed by a set of icons (to represent socio-economic actors as well as the various physical and intangible elements of the S.PSS), arrows (to represent the various types of flows/interactions between the actors), a template to be used in the design process and a set of rules for the visualisation and a set of rules to visualise them. Icon is characterised by colour-coding and a short text describing the actor, product or activity (Figs. 7.27 and 7.28)

How to use the tool

The tool requires the use of a slideshow software (e.g. Microsoft PowerPoint, or the equivalent in Open Office), but a printed version can also be used. The tool is based on some specific rules to be followed (Fig. 4.12) that aim at standardising each S. PSS + DRE model.

Each actor is represented by one icon, made of three elements.

- The structure, which indicates the typology of actor, e.g. private enterprise, public institution, community, etc.
- The colour, which defines the type of icon, i.e. services (light blue), products (green), etc.
- The slogan, which specifies the actor activity: energy solution provider, micro-finance institution, etc (Fig. 7.29).
- The energy solution provider/s, which can include a single actor or a partnership of actors, is represented on the left-hand side of the map and it is characterised by a violet colour;
- The customer is always placed on the right-hand side of the map and it is characterised by a pink colour;
- Ownership of the energy system and energy-using products are described with corresponding colours;
- Flows of products and services are pictured in the top-middle part of the map, showing transactions between provider and customer—Payments are described in the bottom of the map, showing what the customers pay for and what modalities/channels are used;
- In order to facilitate the reading of the map, flows are ordered with progression numbers.

The nature of the flows between the different actors is marked by different arrows (Fig. 7.24):

- The full, thick arrow indicates material flows (components, products, etc.);
- The fine, square-dotted arrow indicates information flows;
- The fine, round-dotted arrow indicates money flows;
- The full, thick arrow with a diamond at its tip indicates workflows (Fig. 7.30).

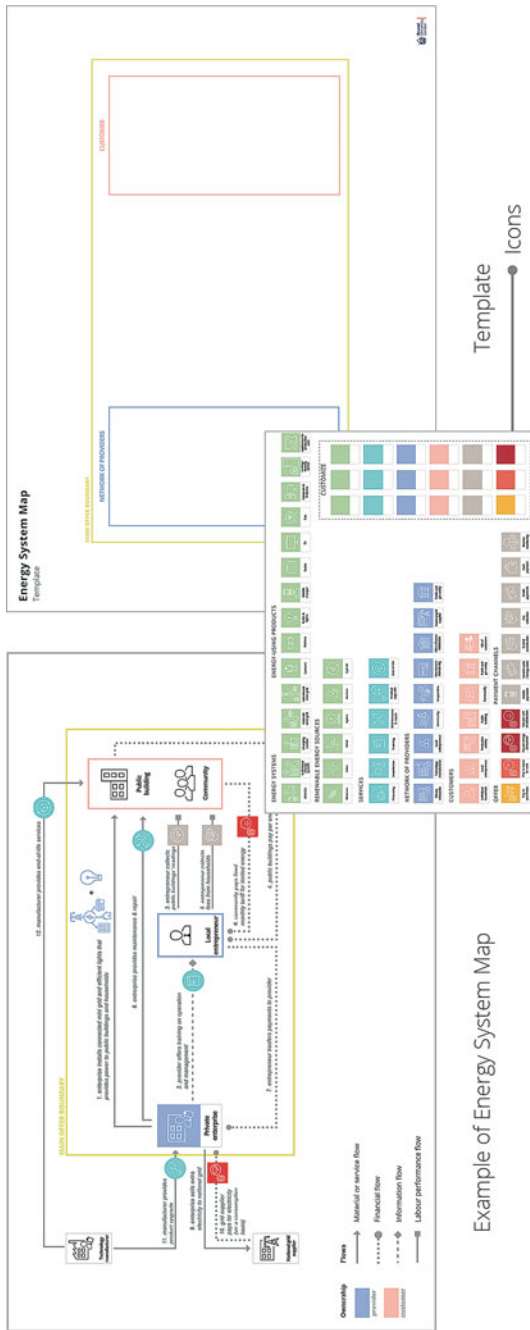


Fig. 7.27 The energy system map tool: icons, example and template. Source designed by the Authors

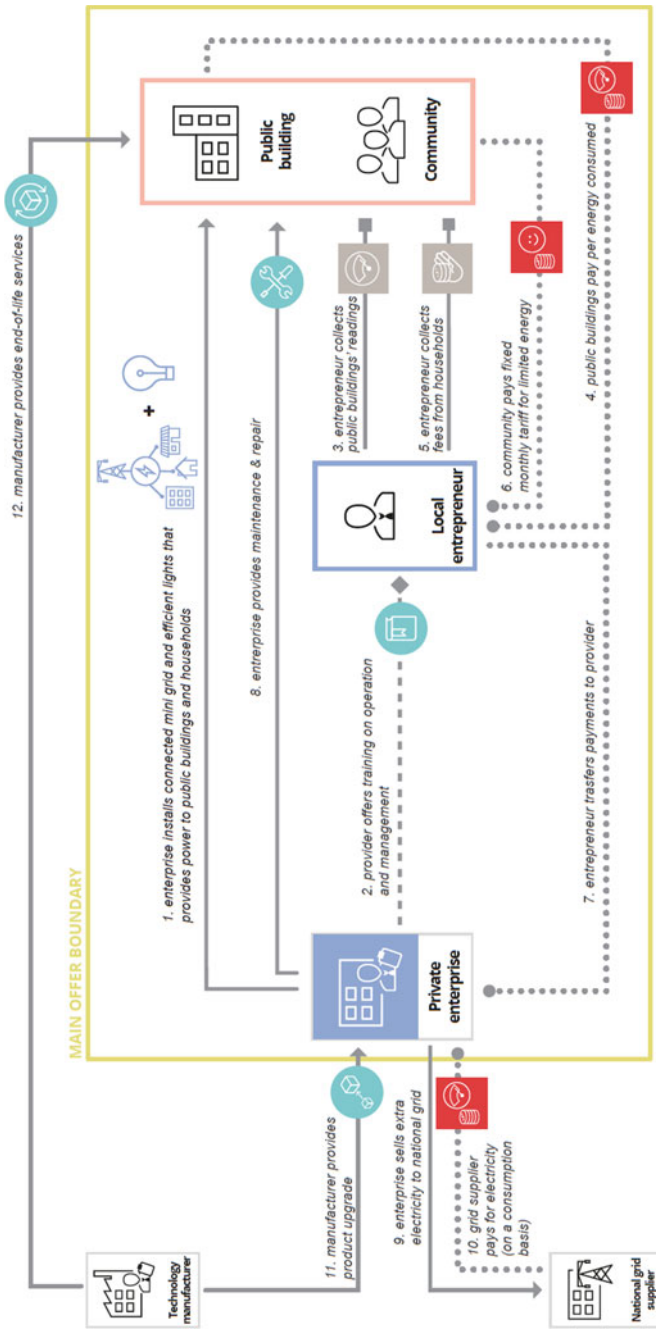


Fig. 7.28 Example of energy system map. Source designed by the Authors



Fig. 7.29 Icons. Source Emili [7]



* The product's ownership is highlighted with the colour of provider or customer

Fig. 7.30 Legend for the energy system map. Source Emili [7]

- System boundary by convention, the limit of the slide or the sheet is the boundary of the system, while a ‘main offer boundary’ includes core actors performing the system. Main actors, their relationships and the main offer to customers are represented within a defined area (yellow box). Secondary stakeholders and their involvement in the S.PSS solution can be positioned outside this area, usually represented with smaller icons to indicate their subordination. This would include, for example, financing and regulatory institutions which are involved in supporting the S.PSS solution but they are not directly involved in providing the offer to end-users (Fig. 7.31).

Integrating the tool into the SD4SEA designing process

The Energy System Map can be used at various stages of the designing process. In the **Strategic analysis**, it can be used to describe

- The current stakeholder value chain of the organisation(s) involved in a project;
- The stakeholder value chain of S.PSSs provided by competitors or of cases of excellence.

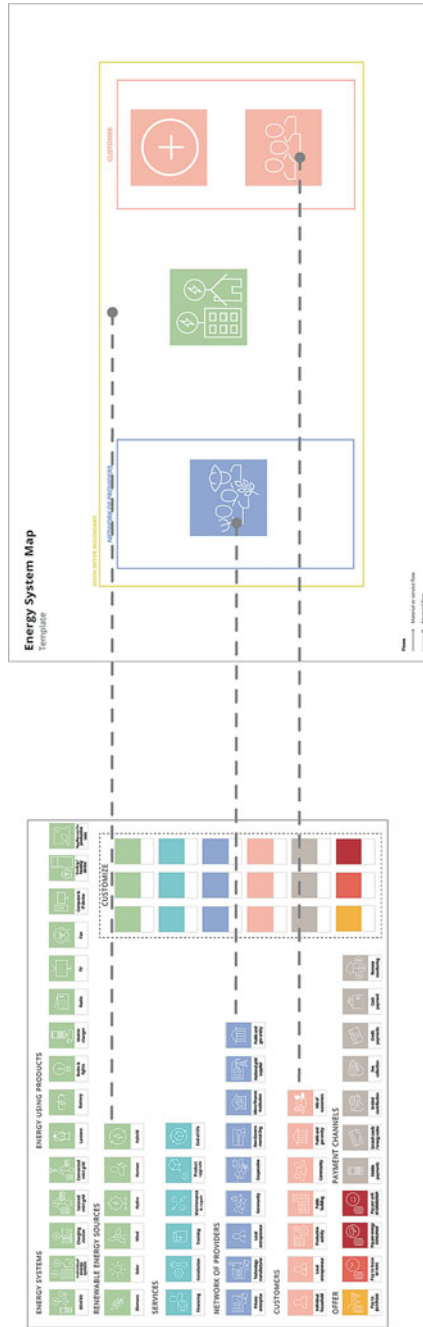


Fig. 7.31 Positioning icons on the template. Source designed by the Authors

In the **System concept design**, it can be used to

- Formalise the initial S.PSS ideas emerging, by visualising the key stakeholders involved in the solution;
- Detail the initial ideas emerging, identifying the main and secondary actors and their interaction flows.

In the **Design System details**, it can be used to

- Further detail the configuration of the system, by visualising all the actors involved and their interactions.

Results

The result is a map that shows the various socioeconomic actors that take part of the system and their interactions (in terms of material, information, money and workflows). This map becomes more and more detailed as the project evolves.

Tool availability and required resources

The tool is available for a free download at www.lenses.polimi.it and on www.se4alldesigntoolkit.com. The tool has been designed to be used in workshops and (co)design sessions, therefore, a printed format is preferable. Alternatively, the tool can be used in its software version (Microsoft PowerPoint), which allows users to modify icons and personalise their Energy System Map. The time required to generate a *System Map* is approximately 30 min. For more complex systems additional time may be required.

7.2.8 Innovation Diagram for S.PSS&DRE

Aims

The Innovation Diagram for S.PSS&DRE [13], is a tool to analyse competitor's energy solutions; as well as to orient the design of new S.PSS applied to DRE concept. The tool allows selection and clustering of (environmentally, socioethically, energy) sustainable ideas within polarity diagram, and starting the design of new S.PSS applied to DRE concepts. Furthermore, it provides the characterization of the designed S.PSS applied to DRE concepts through a set of labels and suggestions. The Innovation Diagram for S.PSS&DRE is presented as a co-design tool favouring a deep understanding of the solution/concept while facilitating collaborative processes and discussions among stakeholders (Figs. 7.32 and 7.33).

What it consists of

The tool is composed by three worksheets for existing energy solutions, for competitors' energy solutions, for new concepts. Each worksheet is based on the following structure: title + proposer + unit of satisfaction + polarity diagram + profile (with labels) + short description. The worksheet for new concepts includes post-it to stick new ideas from the Sustainable Energy for All Idea Tables tool. Two additional worksheets with labels and instructions are available to fill the profile section of the tool.

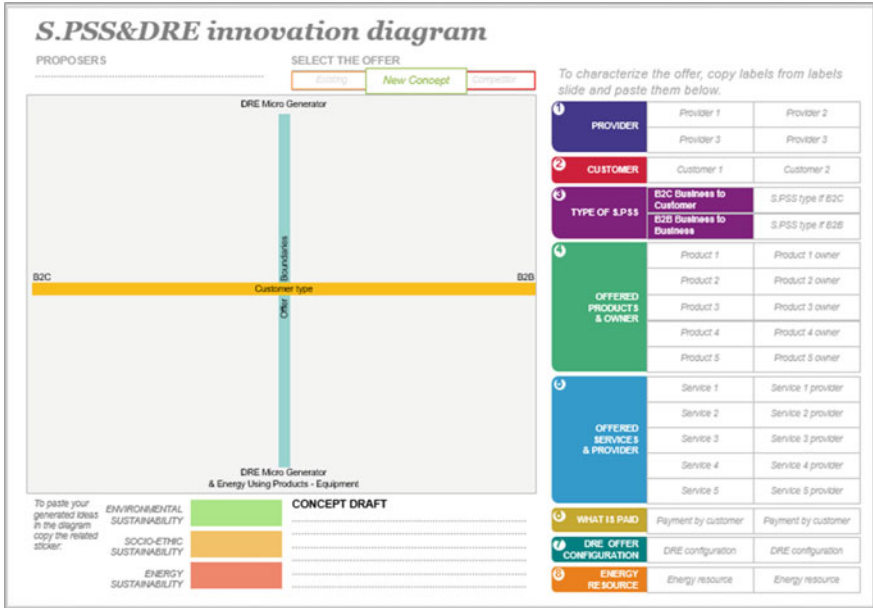


Fig. 7.32 Innovation diagram for S.PSS&DRE. Source designed by the Authors



Fig. 7.33 Labels to support the innovation diagram for S.PSS and DRE. Source designed by the Authors

In each of the worksheet the following could be found:

Title depending on the worksheet the title is the name of the solution/concept that will be explored.

Proposer means the name/s of who is using the tool.

Unit of satisfaction is the need satisfied/to be satisfied (e.g. access to energy, have clean clothes).

Polarity diagram the polarity diagram (same of the Scenario one) is based on four quadrants built on two axes (a) the horizontal axis defines to whom is addressed the solution/concept end user (B2C), or small entrepreneur/small business (B2B) (b) the vertical axis defines how much is extended (boundaries) the solution/offer is related to the Distributed Renewable Energy micro-generator (e.g. solar panel system plus its appliances such as storage, inverter, wires, etc.), or to the sum of both the Distributed Renewable Energy micro-generator and the related Energy-Using Products or Energy-Using Equipment (e.g. phone and television are Energy-Using Products; woodworking machine, sewing machine are Energy-Using Equipment). Due to the variety of actors who can deal with energy solutions, is relevant to consider that actors can play in the polarity diagram even though they are not directly offering Distributed Renewable Energy micro-generator, and neither Energy-Using Products or Equipment. For example, a consultancy on energy services could be positioned on one pole or the other on the typology of energy services.

Profile (with labels) the profile presents a table with empty spaces to be filled with the following *key information* regarding the energy offer³:

- *Provider/s* it refers to the providers involved in delivering the energy solution and could be one as alone actor or a partnership of providers and includes energy companies, NGOs, energy consultancies and others;
- *Customer/s* it refers to the customer of the energy solution and can be a final customer (B2C) as a household, a community, a school, and so on; or a small entrepreneur/small business (B2B) such as a company, a local shop and others;
- *Type of S.PSS* it refers to the type of S.PSS applied to the energy solution and could be Product-oriented (pay-to-own + additional services as installation, maintenance, repair, and others) or Use-oriented (pay-to-lease/share + training to install, maintain, manage and so on) or Result-oriented (pay-per-use to reach a specific final result/satisfaction unit);
- *Offered product/s (and related ownership)* it refers to products which are included in the energy solution and integrates both the DRE generator (e.g. solar panel + wires and storage) and the Energy-Using Products or Equipment (e.g. a phone is a Product; a sewing machine is an Equipment). It is required to define the ownership of the products included to lately verify the innovative and sustainability value of the energy solution;

³To increase readability of this section, we will use the term 'energy offer' both to refer new concepts or to existing energy offers, or competitor's energy offers.

- *Offered service/s (and related provider)* it refers to services which are provided by the energy solution such as financial services, training services, maintenance services and so on. It is required to define who among the stakeholders is delivering the service to define and verify the role of each stakeholder in the energy solution;
- *What is paid* it refers to what the customer (B2C–B2B) pays to access the energy solution as pay-per-period, pay-per-use, pay-per-time, in-kind payment, payment with financial support, or a mix of different payments;
- *DRE system configuration* it refers to how the energy solution is structured. The options include distributed stand-alone system (e.g. solar home system, solar lantern), decentralised stand-alone system (e.g. energy recharging centre), distributed-decentralised systems connected through mini-grid as well as distributed-decentralised systems connected to the main-grid;
- *DRE source* it refers to the energy source used to power the energy solution as solar, wind, hydropower, biomass, and others and could be a single source or an integrated mix of them.

Labels and instructions

The labels are divided as per the profile key information (see above) and offers for each of them a series of variable solutions, e.g. for the customer there are several labels such as, community, household, etc., the same is for all key information. To facilitate the use of the label a question and guideline for each key information is provided.

Short description

The short description is no more than 200 characters, to be used to present the solution/concept highlighting the main innovation and sustainability value.

Post-it

Post-it are available in the worksheet for new concepts to stick new ideas, or ideas from the Sustainable Energy for All Idea Tables contained both in a dedicated file and in the Sustainable Energy for All section of the SDO toolkit tool.

How to use the tool

The Innovation Diagram for S.PSS&DRE tool requires the use of a slideshow software (e.g. Microsoft PowerPoint, or the equivalent in Open Office) or can be used in the printed version. According to the aim of the design activity, the corresponding worksheet/s need to be used.

How to analyse existing or competitor's energy offers:

First, write proposer/s name/s of who is working on it and the unit of satisfaction (e.g. access to energy, in the rural area, for home use). Second, position the existing and the competitor's offers (in the two worksheets) in the polarity diagram according to its customer and offer boundaries. As general rule is not compulsory that the offer correspond to a single position (e.g. B2C–B2B), if the case, is possible to locate the offer in the middle. Third, fill the profile following the instructions provided to copy/paste the labels. Considering that an existing or competitors' offer

is not automatically an S.PSS or is not necessarily offering products and/or services, some spaces in the profile could remain empty. Finally, write a short description of the offer emphasising innovation and sustainability problems.

How to design S.PSS applied to DRE concept

First, write the (draft) title of the concept that is going to be designed, then write the proposer/s name/s of who is working on it and the unit of satisfaction to be met (e.g. access to energy, in the rural area, for home use). Second, copy and paste the most promising ideas from the Sustainable Energy for All Idea Tables tool and position them in the polarity diagram. Creative discussions among the proposers will address the way to position the ideas according to customer and offer boundaries (the two polarity axes). As general rule is not compulsory that one idea corresponds to a single position (e.g. B2C–B2B), if the case, is possible to locate the idea in the middle and to decide after. Third, read all selected ideas and cluster them to create one/more concepts, some ideas if not interesting anymore can be excluded. Then, select the most promising S.PSS applied to DRE concept emerged and fill the profile following the instructions provided to copy/paste the labels. Finally, check coherence of the whole information and write the short description of the concept emphasising innovation and sustainability values. Follow up with discussion on the emerged S.PSS applied to DRE concept.

Integrating the tool into the design process

The Innovation Diagram for S.PSS and DRE can be used in the *Strategic Analysis* and *System concept design* stages of the design process.

Strategic Analysis

In the *Strategic Analysis*, it can be used to analyse and reorient existing energy offers, to analyse competitors' energy offers and even to make a comparison and start to identify potential opportunities.

System concept design

In the *System concept design*, it is used to combine the generated ideas and characterise the new S.PSS applied to DRE concept.

Results

The result in the case of existing or competitor's energy offers is their characterisation, where the lack of S.PSS applied to DRE offers emerge.

Tool availability and required resources

The tool is available for a free download at www.lenses.polimi.it. The tool has been designed to be used in workshops sessions, therefore, if the digital version is used a projector is preferable. In the case, the paper version is preferred suggestion is to print the worksheet as A3 or A2.

The time required to analyse existing or competitor's energy offers is approximately 20 min; in the case of the design of an S.PSS applied to DRE concept is approximately 30 min.

7.2.9 Concept Description Form for S.PSS and DRE

Aims

Concept Description Form for S.PSS and DRE [13] is a tool to visualise and finalise the description and characterization of a new S.PSS applied to DRE concept. The Concept Description Form presents a worksheet where to visualise key information, facilitating a deep understanding of the concept while presenting it among (existing—potential) stakeholders (Fig. 7.34).

What it consists of

The tool is composed of one worksheet with the following fields: proposer, title, unit of satisfaction, short description, profile.

Proposer the name/s of who is using the tool.

Title the name of the concept that is visualised with the tool.

Unit of satisfaction is the need satisfied/to be satisfied (e.g. access to energy, in the rural area, for home use).

Short description the short description is no more than 200 characters, to present the concept highlighting the main innovation and sustainability value.

Profile the profile presents a table with spaces to be filled with text on key information as: customer, provider, type of S.PSS, offered products (and related ownership), offered services (and related provider), what is paid, DRE system configuration, DRE source.

<i>S.PSS and DRE concept description form</i>	
CONCEPT TITLE	PROVIDER
SATISFACTION UNIT	CUSTOMER
CONCEPT DESCRIPTION	TYPE OF S.PSS
	OFFERED PRODUCTS & OWNER
	OFFERED SERVICES & PROVIDER
DESIGNER/S	WHAT IS PAID
	DRE CONFIG

Fig. 7.34 Concept description form for S.PSS and DRE. *Source* designed by the Authors

How to use the tool

The Concept Description Form for S.PSS and DRE requires the use of a slideshow software (e.g. Microsoft PowerPoint, or the equivalent in Open Office) or can be used in the printed version. First, is needed to write proposer/s name/s of who is working on the concept, together with title and the unit of satisfaction met. Second, write the short description of the designed S.PSS applied to DRE concept emphasising innovation and sustainability values. Third, fill the profile table with text for each key information. Follow up with discussion on the emerged S.PSS applied to DRE concept and refine as needed. Generally, if the Innovation Diagram for S.PSS and DRE have been used, most information can be taken there and updated according to the newest version of the concept.

Integrating the tool into the design process

The Concept Description Form for S.PSS and DRE can be used in the *System concept design* stage of the design process. It is used also to present (internally and externally) the S.PSS applied to DRE concept.

Results

The result is the summary of an S.PSS applied to DRE concept, facilitating the concept definition while presenting it among (existing—potential) stakeholders.

Tool availability and required resources

The tool is available for a free download at www.lenses.polimi.it. The tool has been designed to be used in workshops sessions, therefore, if the digital version is used a projector is preferable; in the case, the paper version is preferred suggestion is to print the worksheet as A2 or A1. The time required to summarise an S.PSS applied to DRE concept is approximately 20 min.

7.2.10 Stakeholder Motivation and Sustainability Table

Aims

The Stakeholders Motivation Matrix [10], a tool to visualise motivations of the stakeholders, has been updated [13] as a collaboration between DIS Research Group of Politecnico di Milano (Italy), Makerere University (Uganda) and TU Delft University (The Netherlands) becoming Stakeholders Sustainability and Motivation Table. It is presented as visualisation tool aimed to identify/show: motivations and contributions of each stakeholder; sustainable (economic, environmental, socioethical) benefits from each stakeholder; this facilitating involvement process and strategic conversations addressing various (existing and potential) stakeholders (Fig. 7.35).

What it consists of

The tool is made of four worksheets: the table, two worksheets with guidelines to define environmental and socioethical benefits, a worksheet with icons.

Stakeholders' Motivation and Sustainability Table


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

Fig. 7.35 Stakeholders motivation and sustainability table. *Source* designed by the Authors

Table The table worksheet is made of a table with six columns: stakeholders, motivation, contribution to the partnership, environmental benefits, socioethical benefits, economic benefits and many lines according to number of stakeholders.

Worksheets with checklists these worksheets present environmental and socioethical checklists to address the definition of sustainable benefits by each stakeholder.

Worksheet with icons this worksheet presents icons representing several possible stakeholders, divided as providers and customers, that can be used in the first column of the table to describe each stakeholder.

How to use the tool

For each stakeholder is asked to fill all columns: stakeholders: stakeholder icon and stakeholder name; motivation: motivations for the specific stakeholder to be in the partnership of stakeholders/contribution to the partnership—contribution given by the stakeholder to the partnership; environmental, socioethical, economic benefits—benefits brought from the specific stakeholders in relation to sustainability. Follow up with a preliminary discussion addressing (existing and potential) stakeholders. To fill the environmental and socioethical benefits two dedicated worksheets are available.

Integrating the tool into the design process

The Stakeholders Motivation and Sustainability Table can be used in the *System concept design* and *Design System Details* stages of the design process.

In both cases, it can be used to verify and facilitate the involvement process and to orient strategic conversations addressing (existing and potential) stakeholders.

Results

The result is an informative table of motivations, contributions and potential benefits as way to orient strategic conversations addressing (existing and potential) stakeholders.

Tool availability and required resources

The tool is available for a free download at www.lenses.polimi.it. The Stakeholders Sustainability and Motivation Table requires the use of a slideshow software (e.g. Microsoft PowerPoint, or the equivalent in Open Office) or can be used in the printed version, in this case, printed materials and a pen are sufficient. The tool has been designed to be used in workshops sessions, therefore, if the digital version is used a projector is preferable; in the case, the paper version is preferred suggestion is to print the worksheet as A3 or A2. The time required to fill the information is approximately 10 min for each stakeholder.

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