SUSTAINABLE DESIGN-ORIENTING SCENARIO (SDOS)

for Sustainable Product-Service System (S.PSS) applied to Distributed Renewable Energy (DRE) in low and middle income (all) contexts

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Sustainable Design
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ABSTRACT English

The thesis is framed within the LeNSes project (the Learning Network for Sustainable energy systems, EU funded, Edulink II programme, 2013-2016, www.lenses.polimi.it), aimed at building and diffusing the new discipline of System Design for Sustainable Energy for All, based on promising models of Sustainable Product-Service System (S.PSS) and Distributed Renewable Energy (DRE).

The purpose of the thesis is to design a Sustainability Design-Orienting Scenario to open new visions to PSS designers to develop access to Sustainable Energy for All systems in low and middle-income (all) contexts.

The research and design path have adopted the MSDS method (Methodology for System Design for Sustainability). First phase of the process was the Strategic Analysis (SA) to collect information about promising S.PSS applied to DRE; through the analysis of a number of best practices in terms of environmental, social-ethical and economic sustainability (a format was developed), with specific attention to Energy for All characteristics. Second phase was the Exploring Opportunity, carried out through a workshop, to develop promising S.PSS ideas and clusters, starting the design of SDOS resulting in four main visions, within a two polarities axes diagram: category of customer (B2C-B2B) and configuration of distributed renewable energy (micro generator-energy using product-micro generator).

The four visions designed within the thesis are 1. Energy for all in daily life, 2.“Energize” your business without investment cost, 3.“PAYxUSE” your access to daily life products and energy, and 4. Start-up your business paying x period equipment and energy. Each vision represents a Sustainable win-win configuration; combining socio-cultural, organisational and technological factors; fostering solutions with a low environmental impact, a high socio-ethical quality and a high economic and competitive value throughout Energy for All offer models.

The four visions are represented by a textual description and a set of movies, designed in collaboration with prof. Francesca Piredda (IMAGIS). Each vision is described as well by a set of S.PSS and DRE clusters of ideas and single ideas as well as by a set of best practices.

ABSTRACT Italian

La tesi si sviluppa entro il progetto LeNSes (the Learning Network for Sustainable energy systems, finanziato EU, programma Edulink II, 2013-2016, www.lenses.polimi.it), dedicato allo sviluppo e diffusione della uova disciplina System Design for Sustainable Energy for All, basata su modelli promettenti di Sistemi Prodotto-Servizio Sostenibili (S.PSS) ed Energie Rinnovabili Distribuite (DRE).

Obiettivo della tesi è la progettazione di uno 'Scenario di Orientamento alla Sostenibilità', per aprire nuove visioni per i designer sul tema dell'accesso alle energie sostenibili per tutti; da contesti a basso/medio reddito, a tutti i contesti.

Il percorso di ricerca e progettazione ha adottato il metodo MSDS (Methodology for System Design for Sustainability). Prima fase del processo è stata l'Analisi Strategica (SA) con raccolta ed elaborazione di informazioni a partire da promettenti S.PSS applicati alle DRE; sono state analizzate diverse best practices e nello specifico la loro sostenibilità ambientale, socio-etica ed economica (è stato sviluppato un form); con attenzione alle loro caratteristiche energetiche. Seconda fase è stata Exploring Opportunities, con la realizzazione di un workshop dedicato allo sviluppo di S.PSS applicati alle DRE; con successiva classificazione dei risultati in quattro visioni, entro due assi di polarità: tipologia di utenti (B2C-B2B) e configurazione del sistema energetico (micro generator-energy using product-micro generator).

Le quattro visioni progettate nella tesi sono *1. Energy for all in daily life, 2."Energize" your business without investment cost, 3."PAYxUSE" your access to daily life products and energy, e 4. Start-up your business paying x period equipment and energy.* Ogni visione rappresenta una configurazione win-win di sostenibilità; combinando fattori socio-culturali, organizzativi e tecnologici; promuovendo soluzioni competitive e sostenibili attraverso modelli di offerta.

Ogni visione è rappresentata da una descrizione testuale e un set di video, realizzati in collaborazione con la Professoressa Francesca Piredda (IMAGIS). Ogni visione è descritta anche da un set di S.PSS e DRE classificate, nonché un set di best practices.

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1.

THEORICAL BACKGROUND

1

SUSTAINABLE ENERGY FOR ALL

1.1. INTRODUCTION

Energy surrounds us, it is fundamental to answer to basic human necessities, like cooking, heating, illumination for instances. Energy is also necessary to sustain economic activities like agriculture, industry, transportation and service. Having energy is in fact a necessity to promote growth and economic well being; this is why energy has become a major geo-political and socio-economic issues. Moreover the energy sector has a great environmental impact on the planet, of course there are some energy sources have a greater impact than others. The world population will continue to grow, at least for some few more decades, this means that also the energy requirement is going to increase. The key-point is how the reliable source of electricity is going to be produced. Nowadays, worldwide, 68% comes from fossil fuels (41%coal, 21% gas, 5,5% oil), 13,4% from nuclear fission and 19% from hydro and other renewable resources[1].

[1] *World Energy Outlook 2013*

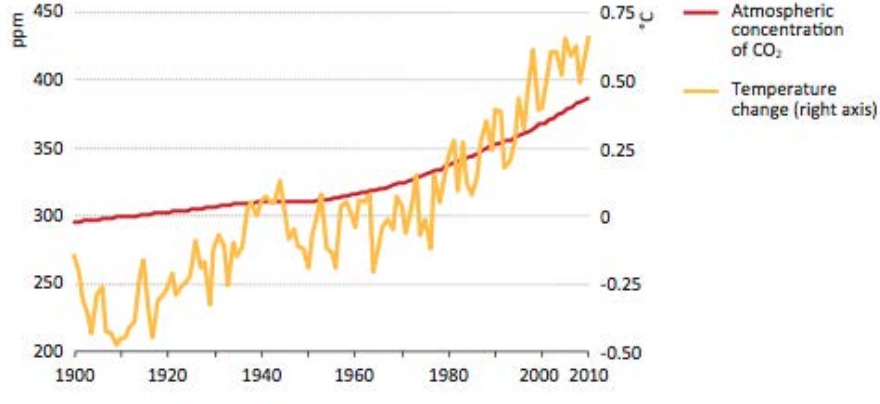
All energy sources have initial financial and environmental costs, but fossil energy is by far the most used source of energy worldwide and the resources are limited, as this resources become less abundant, the price will increase. Moreover fossil energy use is associated with a number of negative environmental effects is likely to contribute to global climate change, but also gives rise to other negative impacts.

To provide well being and meet energy security, there is the need to reduce the use of fossil energy resources; instead low-polluting, renewable and clean energy should be enhanced.

1.2. IMPACTS OF ENERGY USE

The Intergovernmental Panel on Climate Change2 say that currently, energy-related [greenhouse gas] GHG emissions, mainly from fossil fuel combustion for heat supply, electricity generation and transport, account for around 70% of total emissions including carbon dioxide, methane and some traces of nitrous oxide.

Figure 1.1
World atmospheric concetration of CO2 and average global temperature change. From World Energy Outlook 2013



Note: The temperature refers to the NASA Global Land-Ocean Temperature Index in degrees Celsius, base period: 1951-1980. The resulting temperature change is lower than the one compared with pre-industrial levels.

Sources: Temperature data are from NASA (2013); CO_2 concentration data from NOAA Earth System Research Laboratory.

These emissions increase global temperature. Green house gasses is a natural phenomenon, but during the last century it has been studied an unnatural increase of global temperature caused by the anthropic emission of Greenhouse gasses (Carbon dioxide CO2), this increase has been particularly significantover the last 50 years. Green house gasses from fossil fuel combustion process are the main contribution to global climate change; another cause of this issue is the deforestation of the tropical rainforest. All fossil fuels produce greenhouse gasses emissions when burned. Petroleum, natural gas and coal release large amounts of carbon dioxide (CO2) when they are use.

This fact causes increase in global temperature, raise of sea level, desertification, died of biodiversity and others whether events such as storm, flood, tropical cyclone and heat waves more frequently. Global climate change is already an observe phenomenon today

Climate change effect every part of the world, even the poorest country that are mainly not have considerably contributed to it, especially for them this causes great damage in fact the third world and emerging nations do not have the financial and infrastructural resources to adapt to climate change. The energy impact do not concern only the global climate change, but has a lot of other impact on nature. One of the possible impacts is local air pollution, especially in big city, this pollution can causes different disease, and health issues like lung cancer and chronic respiratory disease. All of this problem al linked to the combustion of fossil fuels because there is the release of chemicals and particulates into the atmosphere during combustion. This pollutants include carbon monoxide, sulf dioxide, chlorofluorocarbons and nitrogen oxides. The primary agent of acid rain is sulfur trioxide

SO_3 , this phenomenon can have harmful effects on plants, aquatic animals and infrastructure. This is mainly caused by the combustion of coal and oil. Other possible impacts implicated in the use of fossil fuel are the destruction of nature, for example Oil spills, especially at sea, can damage ecosystems. Moreover extractions of fossil fuels cause destruction of landscape and biodiversity and last but not least geopolitical conflicts and wars caused by the wish to control energy resources.

All these impacts demonstrate how meaningful sustainable energy transitions could be especially for developing countries.

1.3. EXTENSIVE GRID OR DISTRIBUTED GENERATION, RIFKIN

There are divergent opinion of what concern energy distribution, some expert assumes that the demand will continuously be served by extensive grid system, but other like Jeremy Rifkin in his book "The third industrial revolution" imagine a future where the strongest trend is the distributed generation system. Jeremy Rifkin is the author of a lot of books about the impact of technology and science on the economy; he is a professor of the University of Pennsylvania and president of the Foundation on Economic Trends. Rifkin has a vision, he is imagining hundreds of millions of people producing their own green energy and sharing with others in exact same way we are now sharing information online a "energy internet". He define this revolution "The third industrial revolution".

"Revolutions always happen when two things meet: new energy regimes and new communication system." (Rifkin 2013)

Figure 1.2
Distributed energy rappresentation

The first industrial revolution came when the new energy regimes, use of coal and the new communication system, the railway network and the spread of printing, meet. As well as the second industrial revolution cam thanks to the meeting of the centralized energy oil and electricity and the mass communication system, like radio, telephones and TVs. The new energy system that will characterized the Third industrial revolution is related to renewable energy, solar, wind and etc. And the new communication revolution that is already happening is connected to Internet and social media

To be more specific the new business model will concern in a sort of peer-to-peer approach inspired by internet, Rifkin describes few changes that will happen in the next 25 years; in fact he assumes that the energy cost (and not the labour cost will entrenched in our production. This energy revolution will create a new sustainable way of living our planet, where people in homes, offices and industries will generate their own energy and they will share it.
Rifkin also assumes that this revolution will take off more quickly in developing world, for many reasons. First off all they start from scratch, there is not in fact, in many places, an existing centralized grid; moreover there is the need to energized many rural areas and without the possibility to attach to the grid many households and commercial activity has to rely on sustainable energy.

In the developing countries, political leaders are promoting renewable energy as rapid but effective way to answer a much needed request of energy, to push the economy.

1.4. ENERGY TRANSITIONS AND THE ROLE OF RENEWABLE ENERGY

Energy transition means a shift from the economic activities based on kind of energy to on other. It has been described the high environmental impact in the use of fossil fuel; this means that a transition from this energy resource to another with less impact is needed.

"Sustainable development is development that meets present needs without compromising the ability of future generations to meet Their own needs"[2]

[2] United Nations Department of Public Information,2005

The answer relies on renewable energy, often called "green energy" or "clean energy", this is because they do not have environmental impact such as Green house gasses emission during energy generation. They are the provision of energy that meets the needs of the present without compromising the ability of future generations to meet their needs. This does not mean that they do not cause damage to the environment, in fact if we consider the entire life-cycle of the energy production there will be Green house gasses emissions from the production, transport and waste phases, anyhow these technologies are close to zero-carbon technologies.

The use of fossil fuel resourced now is more cheap that invest in renewable form of energy, but it's becoming more and more expensive so in a long term point of view is definitely beneficial to invest in alternative form of energy. The world sustainability is not only referring to and environmental point of view, but we as human being have to change also

our behaviour. In fact use “green energy” is cannot be a solution itself, but there is the need to reduce the amount of energy used by person considering what effects it might have on the planet.

Renewable and clean energy are safe for the environment and for human health, they can also provide energy in rural areas in fact they can be use in areas where there is no grid connection and people has to rely on traditional biomass: wood, dung and agricultural residues.

“There is a high potential for renewable energy worldwide, however, only a small percentage of this potential is exploited so far” (Hoogwijk, 2004)

As a conclusion the energy transition is needed to provide to the future generation a safe environment and new possibility to developing countries.

1.5. TYPOLOGY OF RENEWABLE AND SUSTAINABLE ENERGY

Renewable energy comes from natural sources that are constantly and sustainably replenished. The technologies featured here will make our families healthier, more secure, and more prosperous by improving our air quality, reducing our reliance on fossil fuels, curbing global warming, adding good jobs to the economy and -- when they're properly sited -- protecting environmental values such as habitat and water quality. Working together, policymakers, communities, businesses, investors, utilities, and farmers can help build a sustainable future for America and the planet.

SOLAR POWER

Solar power is energy from the sun that is converted into thermal or electrical energy. Solar energy is a flexible energy technology: solar power plants can be built as stand alone, local micro grid and main grid connected.

Every hour the sun beams onto Earth more than enough energy to satisfy global energy needs for an entire year. Many people are familiar with so-called photovoltaic cells, or solar panels, found on things like spacecraft, rooftops, and handheld calculators. The cells are made of semiconductor materials like those found in computer chips. When sunlight hits the cells, it knocks electrons loose from their atoms. As the electrons flow through the cell, they generate electricity. But solar energy doesn't work at night without a storage device such as a battery, and cloudy weather can make the technology unreliable during the day. Solar technologies are also very expensive and require a lot of land area to collect the sun's energy at rates useful to lots of people.

Photovoltaic (PV) technologies convert solar radiation direct into electricity. The traditional building block for PV systems is the photovoltaic cell, a thin square plate or film of semiconductor material that measures around 10cm x 10cm. Solar radiation "falling" on the cell induces an electric voltage as a result of the photovoltaic effect. Several cells are interconnected and assembled in PV modules. These modules can be arranged in mounting structures in order to generate more power. In addition to the PV modules, a PV system also requires other devices that are commonly called the Balance of System (BoS). The BoS comprises different electrical components, such as wires, a DC-AC inverter, a controller and switchboards (in the case of on-grid systems), batteries and a charge controller (for off-grid systems), and structural elements, such as mounting structures or sun-tracking systems. A schematic view of an offgrid system is shown in Figure

Small-scale off-grid systems

Two billion people living in rural areas lack access to the national electrical grid. These people mostly live in areas that are impossible to connect to a public grid. In many cases, a connection to the national grid is too expensive due to long transmission distances and the resulting costs. Small-scale off-grid systems are an economical alternative to a grid connection and provide people in remote locations with a reliable and continuous energy supply. The example shows a system consisting of the Sunmodule SW 50 poly RMA, a charge controller and a battery. housands of rural homes and shops have been equipped with such systems and the owners can now light their homes or shops and charge their cell phones, power their radios or similar appliances.

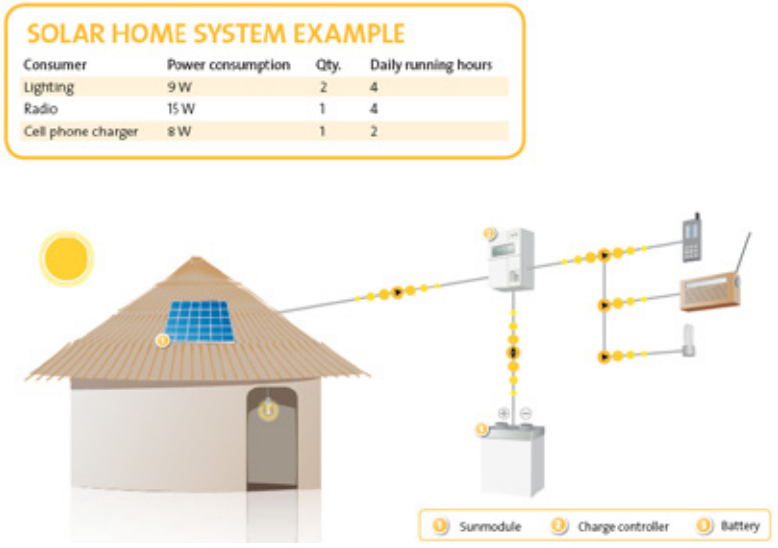
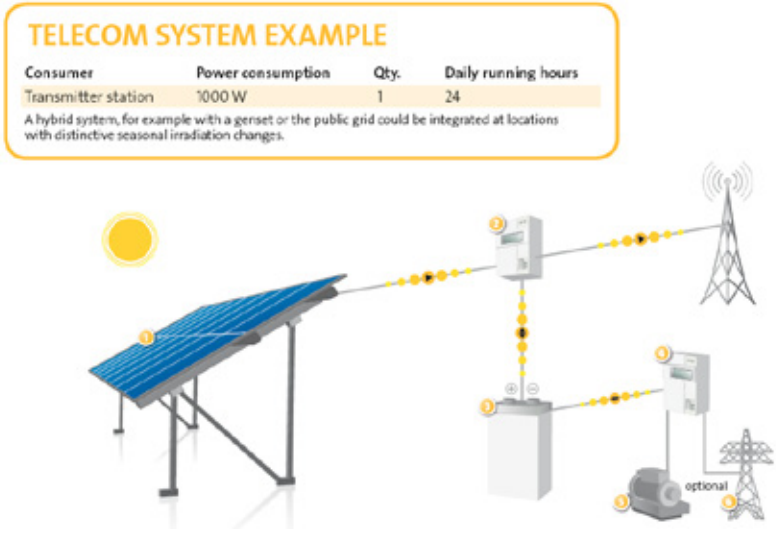


Figure 1.3
Schematic view of a small-scale off-grid systems; SolarWorld www.solarworld.com

Figure 1.4
Schematic view of a medium to large off-grid systems; SolarWorld www.solarworld.com



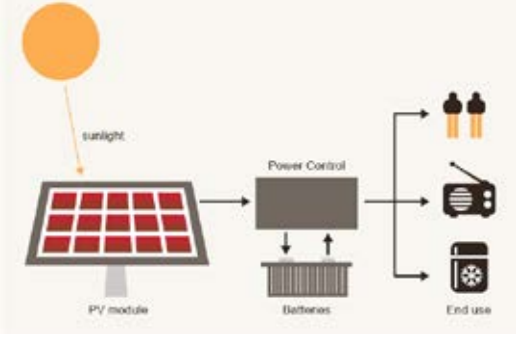
Medium to large-scale off-grid systems

Imagine being able to power an entire rural village with clean solar energy. The technology to make it happen has not only arrived – it has been around for years. Industrial applications can also benefit from this kind of solar technology.

The example shows our Sunmodule SW 130/140 poly R6A supplying energy to a telecom company's remote cell phone transmitter station. In providing energy to telecom applications highest standards regarding quality and reliability are required. People need to be able to make phone calls 24 hours a day, 365 days a year. Solar-powered energy supply systems have been proving their reliability in meeting these demands for around 30 years now.

Eco-Efficiency Socio-Ethical Issue:

Several experiences in the dissemination of PV have illustrated the importance of establishing appropriate local technical capacities and regional after-sale systems that can reach all users. Access to technical advice, maintenance and reparation services, availability of spare parts or the means of enforcing warranty agreements can all help to guarantee the long lasting adoption of the solutions. Only well-off people can afford expensive solar home systems without the need to resort to third party funding. This may lead to envy and increased social disparity.



Eco-Efficiency Environmental Issue:

The operation of photovoltaic technologies can be considered as emission free. The technology's main environmental impact relates to the production and later the recycling and disposal of the photovoltaic devices. Although the current flow of photovoltaic waste is rather insignificant, the recycling and disposal of photovoltaic components is expected to become a crucial issue over the next ten years. The sector seems to be aware of this challenge and some technologies to deal with these disposal issues have already been developed and tested. Recycling policies and regulations are expected to lead to the establishment of proper take-back systems in the biggest PV markets around the world.

Figure 1.5
Schematic view of a PV-System for off-grid applications

WIND POWER

Wind power systems transform wind energy into mechanical or electrical energy. Wind turbines are the main component of wind power plants. Modern wind turbines use the aerodynamic lift principle, i.e. the same principle applied to generate the lift forces on the wings of aircrafts. The wind flow passes over the rotor blades of the wind turbine generating a lifting force that makes the rotor rotate.

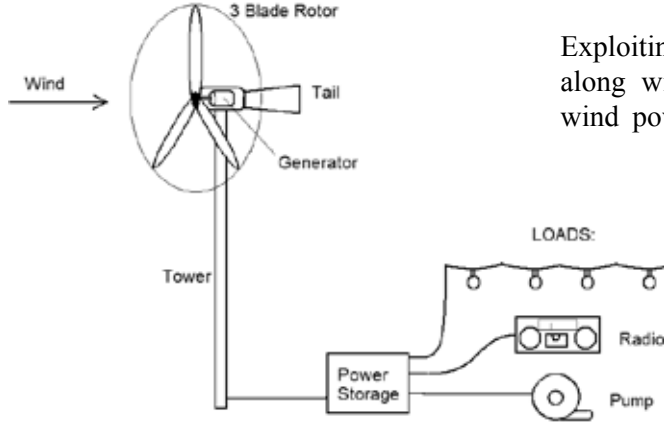


Figure 1.6
chematic view of a wind power system for off-grid applications

Equipment and strategies to regulate power generation areimportant components of modern wind power systems. These perform functions such as the optimisation of wind resources utilisation, the protection of the system in the case of extreme winds and the monitoring of the system in order to assess the need for maintenance or repairs. Additionally, wind power systems for off-grid applications commonly include storage capacities

Exploiting offshore wind power potential, along with the rapid growth in onshore wind power, and integrating wind power

properly into electricity networks will be the key issues for developing the global potential for wind.

Eco-Efficiency Socio-Ethical Issue:

Lessons learned from community-based wind projects stressthe need for developing local technical skills and for the involvement of the local population in the development of the system. Training local technicians may guarantee the smooth operation of the systems. A well functioning wind system becomes an object of pride for the community, especially when individuals' efforts have contributed to the construction. When local plants for the manufacture of equipment are established, an increase in the regional employment potential can be expected.

Eco-Efficiency Environmental Issue:

Wind power generates no CO2 emissions other than small amounts in the production and installation of turbines. The technology has no water needs. However, wind power has an environmental impact at a local and regional level. This is mainly due to the visual impact, which can include shadows from the rotating turbine blades, noise from the turbines and the risk of bird collisions and disruption to wildlife. These potential disadvantages may be alleviated by careful selection, design and operation of the site.

HYDRO POWER

Micro-hydroelectric plants are appropriate for the provision of electricity where the demand for power is relatively low (e.g. below 100 kW) and where a constant flow of running water is available. Micro-hydro projects are commonly designed in "run-of-river" schemes, i.e. configurations where only part of the water flow of a stream or river is deviated to drive the hydroelectric units.

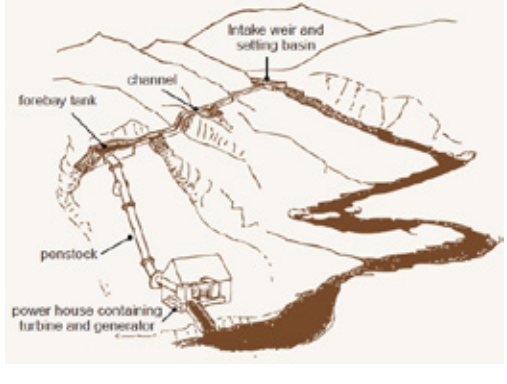


Figure 1.7
Typical configuration of Micro-hydro plants. Source: Practical Action, technical brief on micro-hydro power

As in other hydroelectric options, in micro-hydroelectric plants the flow of water turns a water turbine. The turbine drives an electric generator, which transforms the rotary movement of the turbine into electricity. The total power delivered to the turbine is proportional to two factors:
1. the rate of water flow, and
2. the hydraulic head of the plant, i.e. the difference in elevations between the water level of the water source and the turbine outflow.

In regions where water flow is readily available, micro-hydro can be used to improve the provision of electricity or even to meet the electric power needs of local populations and/or industries. The technology is suitable for feeding both off-grid configurations and grids in distributed schemes. Micro-hydro can, therefore, be an important component of the energy development plans in many countries.

Eco-Efficiency Socio-Ethical Issue:

The development of a micro-hydro project can lead to synergies or conflicts with other issues. For example, a micro-hydro project can be integrated into programmes addressing other local needs such as irrigation, flood prevention, flow regulation for navigation or the fostering of tourism activities. On the other hand, the operation of a micro-hydro plant can also result in conflict: competition with other programmes for the use of water flow or negative effects such as floods or an insufficient water flow downstream of the plant.

Eco-Efficiency Environmental Issue:

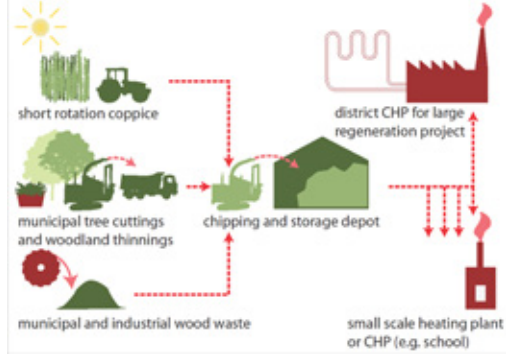
Greenhouse gas emissions associated with the operation of micro-hydroelectric plants are considered to be marginal. However, the operation of micro-hydro plants involves modifications to the natural water flow. In the case of "run-of-river" schemes, only a section of the stream will be used (i.e. between the intake weir and the outflow of the turbine). In the case of schemes that use reservoirs, the operation of the plant affects the water flow downstream of the dam. Changes in the water flow can have a critical impact on the habitats of local species (e.g. fish, birds and mammals).

BIOMASS

Figure 1.8
Schematic view of some transformation paths to generate electric power from biomass

Biomass is human civilisation's most ancient source of energy. It can be produced in forestry (woody biomass), in agriculture (energy crops) or form part of the waste derived from different kinds of processes (biomass residues). Biomass resources can be found or produced in almost any part of the world. There are several technological ways to transform the energy content of biomass into electricity. The transformation process consists of at least four main stages:

1. Biomass supply includes traditional activities of the agriculture and forestry sector, e.g. land preparation, cultivation and harvesting, or the collection of the useful organic fraction from different waste flows, e.g. municipal or industrial wastes.
2. Biomass conditioning, i.e. the processing of the resources to make them suitable for use by energy conversion technologies. It may include processes like size reduction, cleaning and drying.
3. Energy conversion of the biomass's energy content into electric power, e.g. through an engine-generator set or a fuel cell.
4. Transport and storage may be necessary between the stages outlined above.



Eco-Efficiency Socio-Ethical Issue:

Biomass resources play a key role in economic and social development. Critical issues are directly related to technical know-how and the management of biomass resources, including food security, land use, ownership and agricultural and forestry development. Therefore, the introduction of new energy technologies that use biomass has a direct impact on social development at local, regional or national level.

Eco-Efficiency Environmental Issue:

Biomass residues can be collected as a by product or waste from agricultural, forestry and industrial activities, as well as a fraction of municipal solid waste. The use of this source of biomass does not usually imply any significant additional environmental threat. Rather, in some cases, it represents a useful alternative to waste that can otherwise become a source of contamination unless it is disposed of properly.

2

PRODUCT SERVICE SYSTEM DESIGN FOR SUSTAINABILITY

" the design of the system of products and services that are together able to fulfil a particular customer demand (deliver a 'unit of satisfaction') based on the design of innovative interactions of the stakeholders (directly and indirectly linked to that 'satisfaction' system) where the economic and competitive interest of the providers continuously seeks both environmentally and socio-ethically beneficial new solutions. "
(Vezzoli et al.2014)

2.1. SUSTAINABLE PRODUCT SERVICE SYSTEM (S.PSS) DESIGN

PSS design for sustainability: approaches and skills

Thus far, the introduction of PSS innovation for sustainability into design has led design researchers to work on defining new skills of a more strategic nature, which aim at system sustainability through a strategic convergence of interests and are coherent with the satisfaction-based approach. 'Strategic' here also refers to the necessary acknowledgement of cultural contexts and inherent opportunities and barriers built into the social fabric.
The main approaches and skills of Product-Service System Design for Sustainability are:

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

There is not one single product to be designed (assessed), but rather all the products and services (and all the related processes) associated with the fulfilment of a particular (customer) demand of satisfaction

The design of particular satisfaction

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

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

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

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

Finally, in parallel with the introduction of the concept of the functional unit for product Life Cycle Design, a satisfaction unit could be introduced. If we take the example of a car the following functional unit could be defined: the transportation of one person per km (possible with a car). If we consider the satisfaction that a car could provide, we may in fact identify several satisfaction units, for example:

- Satisfaction unit 1: one person having access to her/his working space (per year)
- Satisfaction unit 2: one person having access to public services delivering personal documents (per year)
- Wider (more products, services, stakeholders to be considered)
- Narrower (looking at one final customer satisfaction)

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

2.2. PRODUCT-SERVICE SYSTEM DESIGN: A PROMISING MODEL FOR SUSTAINABLE DEVELOPMENT

Product-Service System: eco-efficiency opportunities for industrialized contexts

Over the last few years some design research centres have reset part of the debate on design for sustainability starting from system innovation. They have done so by through a stringent interpretation of environmental sustainability that requires a systemic discontinuity i.e. radical innovation in the production and consumption patterns. Accordingly, a significant ambit in which to promote radical changes for sustainable consumption seems to be the widening possibilities for innovation beyond the product. More specifically, this entails innovation of the system, which entails an integrated mix of products and services that together are able to satisfy a particular demand of the customer (Goedkoop, van Halen, Riele, Rommes, 1999; Brezet, 2001; Charter, Tischner, 2001; Manzini, Vezzoli, 2001; Bijma, Stuts, Silvester, 2001).

This integrated mix is referred to in this context as a Product-Service System (PSS) which can be defined as 'a system of products, services, network of actors and supporting infrastructure that continuously strives to be competitive, satisfy customer needs and have a lower impact than traditional business models' (Mont O., 2002). More recently, in the United Nations Environment Program publication (UNEP, Tischner, Vezzoli, 2009), a PSS is defined as 'a system of products and services (and related infrastructure) which are jointly capable of fulfilling client needs or demands more efficiently and with higher value for both companies and customers than purely product based solution'. The following case exemplifies what written above

An example of PSS in industrialized contexts.
Pay Per Page Green—Ricoh

Ricoh offers a package deal (Pay per Page Green) and installs, maintains and collects at the end-of-life the printers and photocopiers (not owned by the customer); the customer pays for the number of delivered pages and copies. The innovative interaction between the company and the client provides the company's economic interest to provide (and design) long-lasting, re-usable and recyclable photocopiers.
Components are tested and functional parts are re-manufactured or directly re-used in a new photocopier. Damaged components are directed to material recycling. Ricoh products are designed to allow component compatibility between different models and to facilitate the whole processes of re-using or re-manufacturing.

A commonly shared opinion is that "PSS could decouple the creation of value from consumption of materials and energy and thus significantly reduce the life-cycle environmental load of current product systems". Eco-efficient PSS can be said to derive from a new convergence of interest between different stakeholders, where innovation is not only happening at a product (or semi-finished) level, but at the interactive and partnership level. In this way, a value production system includes the value chains of a firm's supplier (and their suppliers all the way back), the firm itself, the firm's distribution channels, and the firm's buyers and is presumably extended to the buyers of their products as well (Porter, 2006).

Sustainable Product-Service System main characteristic

Satisfaction-based

They are rooted in a satisfaction-based economic model, i.e. each offer is developed/ designed and delivered in relation to a particular customer "satisfaction" (unit of satisfaction);

Interaction-based innovations

They are stakeholder interaction-based innovations, i.e. they are radical innovations, not so much in technological terms as in new interactions/partnerships between the stakeholders of a particular value/satisfaction production system;

Eco-efficiency potential

They have an intrinsic eco-efficiency potential, i.e. they are innovations in which it is the company/companies' economic and competitive interest that may lead to a reduction in environmental impact (system eco-efficiency: decoupling the creation of value from resources consumption).

2.3. PRODUCT-SERVICE SYSTEM DESIGN CRITERIA OF SYSTEM ECO-EFFICIENCY

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

It has been already observed that not every system innovation is eco-efficient. Accordingly it is important to adopt appropriate criteria and guidelines as well as methods and tools for embedding them when designing a new system, in order to steer it towards a sustainable solution. Here we therefore propose several design criteria for system eco-efficiency. As a starting point, as defined in the MEPSS[4] EU research project, six criteria can be listed according to their orientation towards eco-efficiency:

System life optimisation

System life optimization refers to the design of stakeholder interactions for a particular satisfaction system leading to extending the sum of the products' lifespan and intensifying the overall sum of the products' use. A product with a longer lifespan, with otherwise similar functions, will generally secure a lesser impact on the environment. A product with a shorter life span will not only generates untimely waste (when the other is still functioning) but will also entail further impact due to the need to replace it. Pre-production, production and distribution of the new product, which would cover the functions of the old one, induce further consumption of resources and creation of emissions.

Piority

- Complement product or infrastructure with services for their maintenance, reparability, substitution
- Complement product or infrastructure with services for their technological up-gradeability
- Complement existing product or infrastructure with services that increase/enable their aesthetical or cultural up-gradeability
- Complement product or infrastructure with services that increase their re-configurability (adaptation in new location)
- Offer shared use services for products or infrastructures
- Offer service delivery platform for product sharing/reuse/second hand selling

Transportation/distribution reduction

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

Piority

- Use digital infrastructures (i.e. internet) for transferring/accessing information
- Create alternative partnerships that enable long distance activities (use, maintenance, repair)
- Create partnerships optimising the use of local resources (info/data transfer)
- Create alternative partnerships that allow on-site production (info/data transfer)
- Merge the product/infrastructure offer, with services for their on-site assembly
- Create partnerships to reduce transportation and packaging of products or semi-finished products
- Merge the product/semi finished product with the service of its transportation to optimise distribution
- Enable clients to reuse packing and reduce transportation
- Offer service that allow remote controlling for maintenance/repair of products

Resource reduction

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

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

Piority

- Complement energy/materials/semi-finished products, with support services for their optimal use
- Offer access to products or infrastructures (enabling platform) through payment based on the unit of satisfaction, fixed fee per given period of time
- Offer full-service (final result) to client/final user, through payment based on the unit of satisfaction
- Provide resources saving technologies and pratices to upgrade existing equipment, where the investment is financed via realized resources saving
- Outsource activities when higher specialisation and technological efficiency of products/infrastructures are available
- Create partnerships to use/integrate existing products
- Outsource activities when higher scale economies are feasible
- Add to product/infrastructure the design of their adaptation in the context of use aiming at resources optimisation
- Complement product/infrastructure, with design services for their adaptation to use in variations of resource requirements
- Offer products/semi-finished products on availability

Waste minimisation/valorisation

Waste minimisation/valorisation entails the design for system stakeholders' interactions to improve the total amount of the system's recycling, energy recovery and composting and reduce the total amount of the waste produced. We use the term recycling when secondary raw materials are used to manufacture new industrial products and composting when secondary raw materials are made into compost. In addition, waste that can be reintroduced into production cycles at added value, i.e. valorising the waste, can be taken into consideration already early in the design process.

Piority

- *Complement product/infrastructure, with take back services aimed at re-using or re-manufacturing*
- *Complement product/infrastructure offer, with take back services aimed at recycling*
- *Complement product/infrastructure offer, with take back services aimed at energy recovery*
- *Add to product withdraw services aiming at composting*
- *Create localised alliances/partnership aiming at symbiotic/cascade approach for secondary resources*

Conservation/biocompatibility

Conservation and biocompatibility entails the design for system stakeholders' interactions that improves the overall amount of the system's resource conservation or renewability. An explanation is needed on resource renewability. Timber is a renewable material, but the same type of wood can be procured from two different areas, where one is under planned and controlled exploitation and the other not, leading to deforestation. The very same material can qualify as renewable in the first case and not renewable/non-reproducible in the other case. It can be summarized that renewability depends on specific re-growing speed and extraction frequency. Therefore we can define that: "a resource is renewable when the consumption rate is smaller than the natural re-growing rate."

Piority

- Create partnership aiming at decentralised, and renewable energy resources

- Create partnerships that increase the utilisation of local renewable and bio-degradable materials and products

- Increase the utilisation of passive energy resources for infrastructure and products functioning

- Create partnerships that increase the utilisation of local recycled materials

Toxicity reduction

Reduction of toxic emissions involves the design for system stakeholders' interactions that reduce or avoid the gross total of toxicity and harmfulness among the resources utilised or emitted by the system. Regarding this criterion it is important to remember that a truly effective approach must always refer to the entire life cycle and to every concurring process of the whole of the products and the support products of a particular system of satisfaction.

This means that various technologies for transforming and treating materials (some of them involving toxic or noxious emissions while others, equally effective, might not) have to be considered along with distribution systems that cause the least harm to the environment and products designed to use energy and consumable resources less invasively.

Piority

- Create partnerships with other producers to reuse or recycle toxic or harmful substances

- Complement the product, infrastructure, or semi-finished products with services that minimise/treat toxic or harmful emissions they cause in use

- Include end-of-life treatments when selling toxic or harmful substances

- Offer toxic managment service to client/ final user, trhogh payment based on the unit of satisfaction

2.4. PRODUCT-SERVICE SYSTEM DESIGN CRITERIA OF SOCIAL EQUITY AND COHESION

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

Improve employment/ working conditions

When speaking about employment/ working conditions we mean a system design that promotes and enhances these conditions (within the enterprise but also at suppliers), e.g. job security, health and safety at work, adequate working hours, fair wages, and conditions enhancing the satisfaction, motivation and participation of the employees. The role of the designer may be marginal in this case: employment and working conditions are issues determined by company goals and requirements. Nevertheless the designer must be aware of relevant issues and active when possible in terms of enhancing, through e.g. various communications means, fair employment and working conditions.

Piority

- Promote and enhance the protection of working conditions
- Promote and enhance health and safety in working conditions
- Promote and enhance adequate working hours and fair wages
- Promote and enhance satisfaction, motivation and participation of the employees
- Define and adopt tools and standard of social and ethic responsibility certification ot the compagnie

Improve equity and justice in relation to stakeholders

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

Piority

- Promote and enhance fair and just partnerships
- Promote and enhance equal and just relations with suppliers, subcontractors and subsuppliers
- Promote and enhance equal and just relations with clients a/o end-users
- Promote and enhance equal and just relations effecting the community where the offer takes place
- Promote and enhance equity and justice with local institutions/agencies

Enable responsible/sustainable consumption

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

Piority

- Make transparent and enhance the social sustainability of all the stakeholders
- Provide the information and/or learning experiences to educate the client /end-user on responsible/sustainable behaviour
- Develop offers that enable responsible/ sustainable participation of the client/end-user
- Involve the client/end-user in the production/ implementation/customisation of his/her own product-service systems towards responsible/ sustainable behaviour
- Involve the client/end-user in the design/ decision process, of his/her own product-service systems towards responsible/sustainable behaviour

Favour/integrate the weaker and marginalised

A system design promoting and favouring (in order to integrate) people such as children, the elderly, the differently abled, the unemployed, the illiterate or any other minority or marginalised social group. Involving and facilitating introduction of foreigners into the social context, developing systems to extend access to goods and services to all social strata, developing systems of shared usage and/or exchange of goods and services to increase their accessibility and developing systems which allow easier access to credit (for companies).

Piority

- Involve and improve conditions of weaker social strata
- Involve and improve conditions of marginalised persons
- Develop systems to extend the access to goods and services to all social strata
- Develop systems of shared usage and/or exchange of goods and services to increase their accessibility
- Develop system which allow easier access to credit (for companies)

Improve social cohesion

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

Piority

- Promote systems enabling neighbourhood social integration
- Promote systems enabling social integration between generations
- Promote systems enabling gender integration
- Promote systems enabling social integration between different cultures

Empower/enhance local resources

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

Piority

- Respect/enhance peculiar local cultural characteristics
- Develop a system to encourage and foster local economiesreinforce the role of the local economy creating services in the same place where they will be used
- Regenerate/enhance unused and disposed artefacts
- Adapt/promote systems using regenerated natural, local resources
- Promote local-based and network-structured enterprises/initiatives

3

SYSTEM DESIGN FOR SUSTAINABLE ENERGY FOR ALL

3.1.PRODUCT SERVICE SYSTEM FOR EMERGING AND LOW-INCOME CONTEXTS

In year 2000 the United Nations Environment Program (UNEP) set up a group of international researchers[1] to both disseminate world-wide the concept of Product-Service Systems innovation, and start exploring new PSS potentialities, which can be summed up in the following queries. The international group of experts engaged by UNEP, has been given the following research working hypothesis:

"PSS may act as business opportunities to facilitate the process of social-economical development in emerging and low-income contexts - by jumping over or by-passing the stage of individual consumption/ownership of mass produced goods - towards a "satisfaction-based" and low resources intensive advanced service-economy" (UNEP, 2002)

To clarify this working hypothesi, look at the example of Product-Service System innovation in low-income and emerging contexts.[2]

[1] The work involved a group of researchers (including the author) from industrialized, emerging and low-income countries; it was set up in 2000 and ended in 2002 presenting the main achievements within the

[2] The cases presented in this chapter come from the already mentioned UNEP booklet of 2002 and from a case databank of the WBCSD, both freely available at their respective

An example of S.PSS based on DRE in low-income context
Distributed Solar Energy and electrical devices as an all-inclusive package, Brazil.
Fabio Rosa founded both a for-profit corporation, Agroelectric System of Appropriate Technology (STA) and a not-for profit organization, the Institute for Development of Natural Energy and Sustainability (IDEAAS). TSSFA developed a basic photovoltaic solar home system and in 2001, Rosa began exploring a new business model to provide Brazils rural people with what they needed: energy services, not just solar energy. To that end TSSFA developed a leasing structure whereby customers pay a monthly fee for the use of cost-effective solar energy packages. TSSFA customers sign a three-year service contract but can end the contract at any time by paying the cost of un-installation. Solar home kits, as TSSFA calls them, include the hardware needed to generate energy, while also providing the installation service and products that use the electricity generated by the solar home system, such as lighting and electrical outlets. All of the tangible inputs are owned by STA and only the service provided by these materials are leased to customers. It is environmentally sustainable because it uses the solar energy; it is socio-ethically sustainable because give to poor people access to useful services; it is economically sustainable because is a business for TSSFA company.

The case presented shows Product-Service System innovation as an approach applicable even in emerging and low-income contexts. Others could be made, nevertheless the followingarguments can be highlighted in support of this hypothesis[3] .

[3] UNEP, 2002, This hypothesis has also been examined in a series of case studies, collected by the group engaged by the UNEP.

First of all, if S.PSS are eco-efficient at system level it means that they may represent opportunities, for a context with fewer economic possibilities, to respond with a lower overall cost (more easily) for unsatisfied social demand.

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

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

Finally, since the development of PSS is based on the building of system relationships and partnerships, they are coherent with the development of network enterprises on a local basis for a bottom-up re-globalization process.

3.2. DISTRIBUTED RENEWABLE ENERGY (DRE) : KEY LEVERAGE FOR A SUSTAINABLE DEVELOPMENT

Energy is the world's largest industrial sector, whose output is an essential input to almost every good and service provided in the current global economy. Yet 1.3 billion people, one in five globally lack electricity to light their homes or conduct business. Twice that number, nearly 40% of the world's population rely on wood, coal, charcoal, or animal waste to cook their food. These sources of energy for cooking produce toxic smoke that causes lung disease and kills nearly two million people a year, most of them women and children (Sustainable Energy for All, 2012). These poor health outcomes along with the lack of access to electricity exacerbate the plight of the poor. The lack of access to modern energy therefore makes it difficult to achieve the Millennium Development Goals[5] of reducing poverty, improving women's and children's health, or broadening the reach of education (Sustainable Energy for All 2012).

Product-Service System Design for Sustainability applied to Distributed Renewable Energy DRE) is a promising approach to help achieve the goal of "Sustainable energy for all" (United Nation)

[5] The eight Millennium Development Goals (MDGs) – which range from halving extreme poverty rates to halting the spread of HIV/ AIDS and providing universal primary education, all by the target date of 2015 – form a blueprint agreed to by all the world's countries and all the world's leading development institutions. http:// www.un.org/ millenniumgoals.

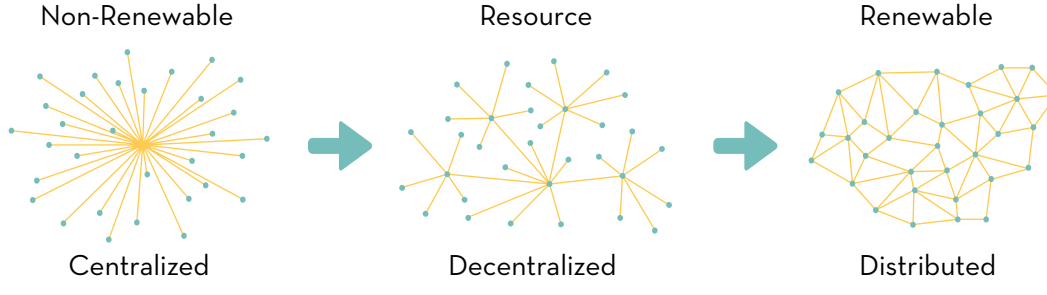


Figure 1.9
shift from non-renewable/ centralized to distributed/ renewable energy generation systems

A Distributed Renewable Energy generation it is characterized by:

- renewable resources: sun, wind, water, biomass, geothermal energy
- small-scale generation plants
- generation at/near the point of use
- users is the producer: individuals, small businesses and/or communities
- if connected with each other to synergically share the energy surplus, they become Renewable Local Energy Network; eventually connected with nearby similar Networks.

Distributed Renewable Energy (DRE) generation could be defined as:

" A small-scale generation plants sourced by renewable energy resources
(such as sun, wind, water, biomass and geothermal energy),
at or near the point of use, where the users is the producer,
whether an individuals, a small businesses and/or a local community
and if a small-scale generation plants is connected with each other
(to synergically share the energy surplus), they become
Renewable Local Energy Network;
eventually connected with nearby similar Networks. "

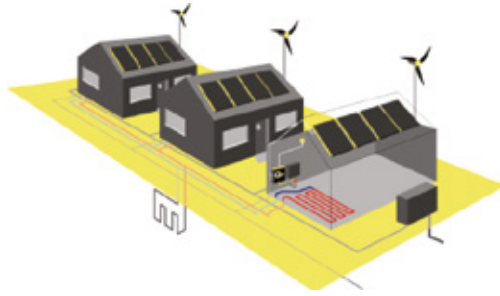


Figure 1.10
A schematic representation of a Distributed Renewable Energy (DRE) generation (www.qurrent.nl)

As an alternative to fossil fuel, the use of locally-based distributed and eventually networkstructured renewable resources, such as sun, wind, water, biomass and geothermal energy, presents indubitable environmental advantages, due to their reduced greenhouse effect (and its impact), inexhaustibility and lower environmental cost compared to the various processes of extraction, transformation and distribution when using fossil fuels. Consequently, the expansive usage of distributed generation of renewable resources could lead to an extensive redistribution of power towards many single individuals, which is necessary to establish conditions that would allow the Earth's riches to be shared more fairly. This is the essence of a policy for bottom-up re-globalization.

The renewable resources can be used locally through relatively simple processes. Technology for these renewable resources has however not been developed in a significant way though the installation and management of photovoltaic (sun) technologies is still infinitely less complex than plants for oil wells and refineries. Photovoltaic technologies are therefore installable and manageable by *small-scale economic entities* such as a single residential complex or single individuals. If adequately exploited then, such renewable resources would enable every human being to have more power and move towards a democratic regime of resource management. These sources would allow micro-plants to be

set up close to the end-user, who would no longer be only a consumer but also producer of the energy he uses. Autonomous photovoltaic panels and combustion cells could supply electricity rapidly and at a favourable cost. When a sufficient number of such micro-plants have been installed (whether purchased or managed), they could be connected together into micro energy-grids, and therefore into a constantly expanding (potentially global) energy grid. Individuals, residential complexes and local communities could in this way share and exchange energy, achieving self-sufficiency and consequently increased power, in a framework of greater interdependence. Ultimately, they could challenge the traditional centralized energy generating plants (born and developed during the age of fossil fuels), and escape the grip of the huge, powerful, energy and electricity companies, causing a radical change in important flows of power: no longer from top downwards, but from bottom upwards.

In short, such a decentralized infrastructure supplied by renewable sources, usually referred to as Distributed Energy Generation (DEG), or Distributed Renewable Energy (DRE), on the one hand would reduce environmental impact, and on the other could facilitate a democratization of resources and energy, enabling individuals, communities and nations to reclaim their independence while accepting the responsibility that derives from their reciprocal interdependence (self-sufficiency and interdependence). Giving access and power to local communities also contributes to enhancing the positive aspects of humanity's cultural plurality, where local cultural forms would aspire less and less to being possessions to defend, and more and more to being opportunities for positive cross-fertilization towards a general improvement in the conditions of life on earth.

Finally, Renewable Distributed Energies (DRE) are increasingly seen (Colombo et al. 2013) as a vital catalyst to achieve universal access to energy and a wider social and economic development by enabling education, health and sustainable agriculture, by creating green jobs and by promoting equity. In other terms, the dissemination of distributed generation based on renewable energies represents an economically viable and effective way to promote sustainable development in low-income and middle-income contexts. Furthermore, the experience gained in developing countries could also contribute to the paradigm shift needed in the energy sector at global level (Colombo et al. 2013).

One of the most committed and known researcher on this topic is Jeremy Rifkin, who is talking about the Third Industrial Revolution (Rifkin 2010). Rifkin core idea is the creation of a renewable energy regime, loaded by buildings, partially stored in the form of hydrogen, distributed via an energy internet a smart intergrid and connected to plug in zero emission transport. Rifkin highlights 5 pillars for this transition:

- Shifting to renewable energy (solar, wind, hydro, geothermal, ocean waves and biomass)
- Buildings as power plants
- Deploying hydrogen and other storage technologies in every building and throughout the infrastructure to store intermittent energies
- Using internet technology to transform the power grid of every continent into an energy sharing intergrid that acts like the internet
- Transitioning the transport fleet to electric, plug in and fuel cell vehicles that can buy and sell electricity on a smart continental interactive power grid.

3.3. SUSTAINABLE PRODUCT-SERVICE SYSTEM (S.PSS) APPLIED TO DISTRIBUTER RENEWABLE ENERGY (DRE) IN LOW-MIDDLE INCOME CONTEXT

"A S.PSS approach may act as a business opportunity to facilitate the diffusion of DRE-based value production system (satisfaction system) in low and middle-income (all) contexts, as a key leverage for a sustainable development process aiming at democratizing access to resources, goods and services."
(LeNSes proposal, EU edulink project, 2013-2016)

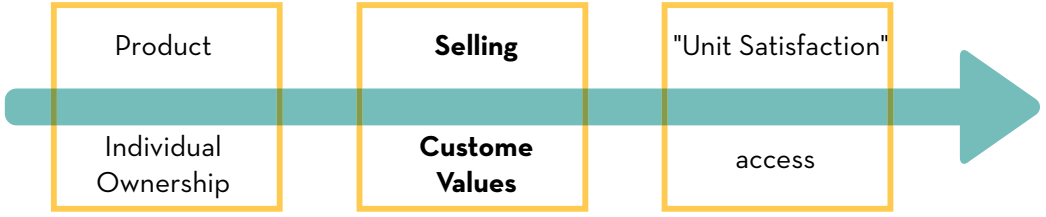


Figure 1.11
S.PSS: win-win business model for a sustainable development

As far as both the models, as well as their combination, are win-win strategies since they canpotentially couple multiple sustainable benefits:

Economic : reduced cost of energy, due to increased resiliency and reliability
Environmental : efficiency gains, reduced emissions
Socio-Ethical : democratization of access to energy, increased participation and independence of local people

An example of S.PSS based on DRE in industrialized contexts. The 'solar heat service', AMG, Palermo, Italy

The 'solar heat service' is a full-service providing a final result, consisting in 'selling' hot water as a finished product. Hot water is produced by new equipment that combines solar energy and methane, with economic and energy savings. Hot water is measured by means of a specific heat meter and the whole system is monitored, in order both to control in real time how the system works and also to apply the Guarantee of Solar Results. The innovative feature of this Product-Service system is that AMG will not invoice the client for the methane consumed to obtain hot water, but rather, hot water is sold as an entire service. With AMG the consumer pays to receive a comprehensive service covering installation, thermal-energy meters and transportation of methane to the boilers. With equipment maintenance provided as well, the customer is buying a 'final result'.Billing is by unit of service and not per unit of consumed resources, the company becomes motivated to innovate in order to minimize the energy consumed in use: the less methane consumed (the higher the use of solar energy and the greater the efficiency of the system) the higher the income for AMG.

3.4. SYSTEM DESIGN FOR SUSTAINABLE ENERGY (FOR ALL)

role for system design for sustainability could be adapted to formulate a research working hypothesis on a new challenging role focused on "unit of satisfaction" powered by a Sustainable Distributed Renewable Energy.

The design of Sustainable Product-Service Distributed Renewable Energy System able to "(em)power" the fulfillment of customer demand/s (DRE-based "unit of satisfaction"), based on innovative interactions of the stakeholders (of the "satisfaction" system), where the economic and competitive interest of the providers, while cutting down the initial investment cost, continuously seeks after both environmentally and socio-ethically beneficial new solutions" (Vezzoli, Delfino, 2013)

System Design For Sustainable Energy For All: Approaches/Skills

Satisfaction-system approach
Design the satisfaction of a particular demand (satisfaction unit) and all its related products and services

Stakeholder configuration approach
Design the interactions of the stakeholder of a particular satisfaction-system

System sustainability approach
Design such a stakeholder interactions (offer model) that for economic and competitive reasons continuously seek after socio-ethical and environmentally new beneficial solution

3.5. THE METHOD FOR SYSTEM DESIGN FOR SUSTAINABILITY (MSDS)

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

The MSDS method has been elaborated within the MEPSS EU project, integrated withoutcomes from the HiCS[2] EU project and refined within the LeNS[3] EU project. It has been used and refined during a series of company consultancy, with Tetrapack company and Kone company and recently in a process of participated design within the Towards a new Intergenerational openness (TANGO) EU funded project (Culture program); four Sustainable Product-Service System has been designed for four suburban districts of Milan, and a set of videos describing them are visible at the following website: www.designtango.eu.

The MSDS method is modular and flexible in order to be adapted to the specific needs of thedesigners/companies and to different context's conditions, nevertheless it is organised in the following phases:

- Strategic Analysis
- Exploring Opportunities;
- Designing System Concepts;
- Designing System Details;
- Communication.

[2] *HiCS Highly Customerised Solutions (2001-2004: European project, 5th Framework Program GROWTH).*

[3] *LeNS, the Learning Network on Sustainability, project funded by the European Union, Asia link programm (2007-2010); in particular by the Design and system Innovation for Sustainability (DIS) research group of the Design department of the Politecnico di Milano, head by Carlo Vezzoli has been the project coordinator.*

Strategic Analysis

Aim
To obtain the information necessary to facilitate the generation of sustainable ideas

Process
- Analyse project proposers and outline the intervention context
- Analyse the context of reference
- Analyse the carrying structure of the system
- Analyse best practices
- Determine priorities for the design intervention in view of sustainability

Exploring Opportunities

Aim
To make a "catalogue" of promising strategic possibilities available, and/or a sustainability design-orienting scenario

Process
- Generate ideas orientated towards sustainability
- Outline a sustainability oriented design scenario (visions, clusters and individual ideas orientated towards sustainability)

Table 1.1
Shows the MSDS aims and processes related the above mentioned phases.

Table 1.1
Shows the MSDS aims and processes related the above mentioned phases.

Designing System Concepts

Aim
To determine one or more system concepts oriented towards sustainability

Process
- Select clusters and single ideas
- Develop system concepts (consisting of one or more product and service mixes that characterize the offer; the relative interaction system between the actors involved; potential environmental, socio-ethic and economic improvements)
- Environmental, socio-ethic and economic appraisal

Design (and engineering) a System

Aim
To develop the most promising system concept(s) into the detailed version necessary to its/ their implementation

Process
- Generate ideas orientated towards sustainability
- Outline a sustainability oriented design scenario (visions, clusters and individual ideas orientated towards sustainability)

Communication

Aim
Draw up documentation to communicate the general,and above all sustainable, characteristics of the system designed

Process
- Draw up documentation in various formats

3.6. SUSTAINABILITY ORIENTING SYSTEM DESIGN TOOLS

THE SDO toolkit

The SDO (sustainable design oriented) Toolkit is a modular software tool that allows to set environmental, socio-ethical and economic priorities, identifying sustainable existing options, generate sustainable focus ideas and check and visualize improvements of the developing concept. The modular software tool has been designed to support the following process: Set the guidelines and priorities analyse the best practise generate sustainable ideas Check sustainability improvement of the developing concept This tool facilitates the process from the analysis of the existing best practise to the evaluation of the final design. It is really useful to orient the concept to a more sustainable level. After the improvements of each criteria have been set, a graphical representation is rendered by the software in the form of a radar. This graphic highlights the main advantages or disadvantages of the project.

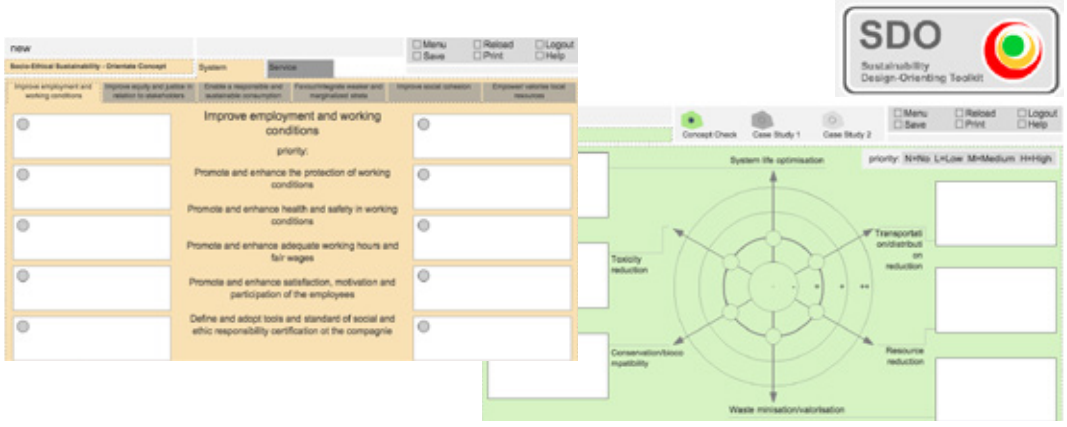


Figure 1.12
Two snapshot of the Sustainability Design Orienting-toolkit (www.sdo-lens.polimi.it.)

The System Map

The system map is a visual description of the service organization and the main and secondary actors involved in the service. Furthermore, their connections and relationships with other stakeholders are shown with arrows. Moreover, flow of materials, information and money are displayed as well. The System Map tool has been developed within the HiCS research project. It supports the design stage and is useful to communicate the system. The system map can be described as codified and progressive: codified because is a technical drawing; progressive because it gives a gradual and accurate picture of the project development. It can not only be used in the strategic analysis to visualize the existing service, but also in the concept design to formalize the initial ideas and in the design engineering system to formalize all the actors involved and their interactions

Figure 1.13
Example of system mao showing Food Atelier, a key component of the system map in specifying the component sub-elements

Polarities diagram

The Polarities diagram was developed to 'explore' the possible and promising directions in which current systems may evolve. In other words it is a tool that supports the definition of how the existing system can be reshaped, starting with specified design choices: it supports the generation of ideas and facilitates their organisation and presentation. It is used, in particular, at the start of the designing process to define and visualise what we call a sustainability design-orienting scenario, i.e. the set of possible and promising reconfigurations that a system may take.

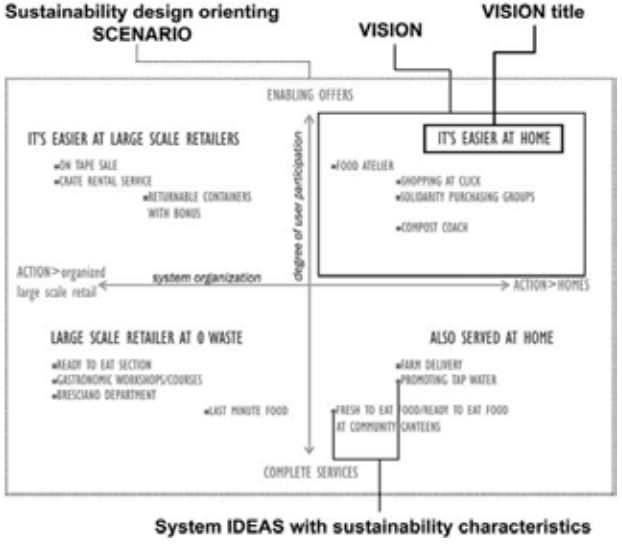


Figure 1.14
Example of polarity diagram showing its component elements
Source: images processed by Vezzoli, Orbetegli and Ceschin 2006

4

LENS.ES
THE LEARNING NETWORK FOR SUSTAINABLE ENERGY SYSTEM

The acronym stands for the Learning Network for Sustainable energy systems. LeNS.es is a multi-polar and open network for curricula and lifelong learning capacity development focused on locally-based Sustainable Energy System Design & Engineering (SES.DE).

In fact, it is based on the on the research working hypothesis highlighted in the previous chapters. Coherently with what has been discussed above, the focus will be on innovative solutions to improve access to cleaner and stable energy services. And in particular on locally-based, renewable, secure, cleaner and economically viable (even to marginalized persons) energy services, based on the promising models of Sustainable Product-Service Systems (PSS) and Distributed Renewable Energy (DRE). In this framework the focus is on extending the access to those people/communities that do not have yet access to energy services (e.g. rural communities) and improving the offer for those who already have access to it (e.g. urban contexts), integrating, in both of the cases, gender equity issues. Moreover there will be a focus also on the use of modern (energy) technologies, and in particular on the most effective and appropriate technologies to manage the generation, storage, distribution and use of renewable energies in locally-based systems. Finally, these issues will be approached from a multidisciplinary and systemic perspective, focusing on: the proper configurations of the socio-economic actors (appropriate partnerships alongside with appropriate technologies) to locally produce, deliver and maintain the energy systems; codesign approaches involving stakeholders including final users.

Figure 1.15
Platform a network promoting an open source and copyleft ethos for knowledge building and sharing base on Product-Service Systems Distributed Renewable Energy (www.lenses.polimi.it)

The Overall objective of the project is to contribute to curriculum and lifelong learning capacity development in System Design for sustainable energy for all, to favour the building up a new generation of practitioners capable of extending the access to locally-based, secure and cleaner energy services, based on the promising models of Product-Service Systems (PSS) and Distributed Renewable Energy (DRE),

The specific objective is to create a multi-polar network among African and European HEIs, to support African HEIs teachers to deliver didactic curricular courses and lifelong learning modules: a network promoting an open source and copyleft ethos for knowledge building and sharing supported by an Open Learning E-Platform (OLEP)
aimed at

- Jointly promoting a new shared disciplinary ground on System Design for sustainable energy for all
- Jointly developing courses/modules, learning resources, tools and guidelines to support educators
- Supporting exchanges among HEIs and practitioners in Africa and Europe
- Ensuring the endurance of the action after the project end.

The visions of this thesis could be considered part distributed renewable energy system of this network since its aim is to be the education tools video designing on the promising model of Sustainable Design Oriented Scenario (SDOS) applied to Product-Service Systems (PSS) and Distributed Renewable Energy (DRE) in the different target place from the official one, the context and design model between LeNSes.

2.

RESEARCH ANALYSIS

1

MOVIE DESIGN FOR SUSTAINABILITY

1.1 VIDEO DESIGN AND PRODUCTION TOOLS

The System Concept Audiovisual

The System concept Audiovisual is a visualisation tool conceived for idea generation; it is able to bring tangibility to ideas in order to shape the design project. This tool enables production of a project output that visualises concepts, which become the starting point for a discussion among the actors. In particular, the tool is a short video format (usually around three minutes) based on a three-act narrative structure

The aim is to show possible concepts and to stimulate imagination and conversation among different actors. System concept Audiovisual has been developed to be a useful tool for the design process enabling the sharing of concepts among the various project participants.

System concept Audiovisual is usually known as Audiovisual Scenario: for further theoretical information see Piredda 2008.

Figure 2.1
Example of how the System concept Audiovisual communicates results

How to use the tool

To support the most effective and creative dialogue, it is recommended that a communication designer works with the design team on these activities:

- Listening: organising the key functions (strengths and weaknesses) into narrative and aesthetic clusters
- Script and storyboard: definition of the storyline and storyboard
- Production of the audiovisual visualisation

In System concept Audiovisual the stakeholders have the main role and cooperate with the design team on the definition of the ideas themselves: they are able to enrich the images' meaning with their ideas, knowledge and experiences.

Phase	***Activity***
Concept	*Listening, Script* *Storyboard, Aesthetic language*
Pre-production	*Material search (images, photos, drawing)*
Production	*Shooting Animation*
Postproduction	*Editing Compositing*

Table 2.1
Phases in use of the System concept Audiovisual tool

Animatic

The Animatic is a visualisation tool able to support the co-design process. It is an animated interaction storyboard that edits images with dialogues and sounds. This audiovisual tool allows the design team to visualise a detailed sequence, giving an idea of the action time. It could be created after and on the basis of a (static) interaction storyboard and could make the same narration more effective. In essence the tool is an audiovisual representation able to:

- Visualise a detailed sequence
- Add information about actions' duration
- Promote a collective conversation among the actors involved

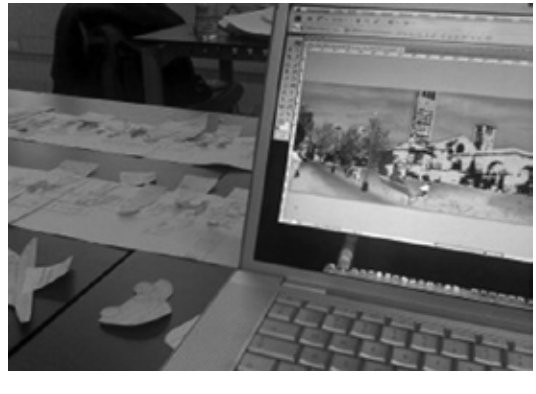


Figure 2.2
Example of a work-in-progress Animatic, a simple video-collage with dialogues and sounds

Integrating the tool into the MSDS designing process when ***Exploring Opportunities.*** Animatic can be used to visualise the different phases of a new idea to make it understandable and facilitate the learning process. It is a semi-finished product that can represent Process and relations in a schematic way and can promote a collective conversation

How to use the tool

Animatic can be used as an internal communication and co-design tool. It is a simple video-collage obtained from a linear editing of drawings and images coming from an interaction storyboard, with dialogues and sounds. For graphic elements it is advisable to use graphic image processing software. For drawing up a storyline able to render the gathered materials the use of slideshow software (e.g. Power-Point or the equivalent in Open Office) or basic editing software is recommended.

Table 2.2
Phases in use of the Animatic tool

Phase	Activity
Concept	Script, Storyboard
Production	Material search (images, photos, drawing) Images processing
Post-production	Linear editing

1.2. TANGO PROJECT

Figure 2.3
TANGO project's postcard

TANGO (Toward A New interGenerational Openness)/ AH-Design project is an European Community (Culture Programme of European Union-Education and Culture DG) financed project which has, as main issue, to explore the issue of social inclusion and in particular the intergenerational dialogue. The project started in September 2011 and will last for two years until August 2013.

The general objective of the Tango project is to promote the social inclusion directly as a part of the design process of the project, involving external participants from the very beginning of the process to plan and develop together the path to design, innovative solutions. In other terms the three partners are carrying out the Tango project as a co-design process involving the local actors, with a key requirement of activating elderly and youngsters, and communities as well as companies, associations and administrations as active parts of the design phases. They will be co-designers, final users or possible partners of the innovations to set the stage for future implementations.

Four master degree thesis projects have been activated in parallel with the SDS course aiming at co-coordinating the co-design process towards the detailed design and incubation of 4 projects of Sustainable Product-Service System, promoting social inclusion and intergenerational dialogue in four districts of Milan, starting from the 4 identified initiatives of the “Punto e Linea” project.

Some of videos show sustainable services that promote dialogue between generation. They are the result of participatory design process promote by Politecnico di Milano (student of the school of Design coordinate by the Design and system Innovation for Sustainability (DIS) Research Unit, Design dept.) in collaboration with th Social enterprise System (SiS) Consortium ("Punto e Linea" project), which has involved individuals, association, companies and local istitution

The design process coordinated by Prof. Carlo Vezzoli has involved four degree thesis students: Sara Hatef, Elisa Bacchetti, Alberto Fossati, Claudio Sarcì (January-December 2012)

SunLight

SunLight, a PSS set-up in Gratosoglio district a team of skilled retired persons able to offer to local primary schools and to their municipality-managed summer camps, a 2 hours
a day services to take and follow the children in a set of sport
activities organised in local parks properly equipped.

https://www.youtube.com watch?v=yqSVKThOK5U

Figure 2.4
SunLight Project in Gratosoglio district, Designed by: Cladio Sarcì, Tutored by: Carlo Vezzoli, Claudio Di Benedetto

2. ShareRadio

Figure 2.5
ShareRadio Project in Baggio district, Designed by: Elisa Bacchetti Tutored by: Carlo Vezzoli, Claudio Di Benedetto

Share Radio (ex)change your time, a PSS that merges in the Baggio district the local webradio with the local bank of time, i.e. the web radio will host a web platform to easy the exchange of specific job among local inhabitants base on time (of job) exchange. The persons, especially retired and youngsters, giving job/hours to the radio, will gain time credits.

https://www.youtube.com/watch?v=6wBODY7wIKk

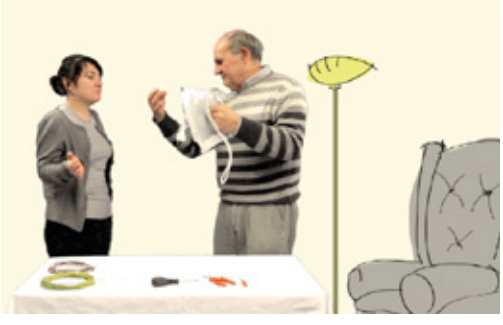
3. CaseVerdi.net

Figure 2.6
CaseVerdi.net Project in Giambellino district, Designed by: Alberto Fossati, Tutored by: Carlo Vezzoli, Claudio Di Benedetto

CaseVerdi.net, a PSS set-up in Giambellino district a team of skilled retired persons cultivating in their balconies/gardens a set of niche gardening products with a high value; to be exchanged within the community or sold to the neighborhood to specific shops or restaurants (with a market price). The platform, placed in la casetta: over check and manage the distributed gardens and its produces; put in contact persons

https://www.youtube.com/watch?v=hYgvGrkbiEO

4. ReMade in Barona

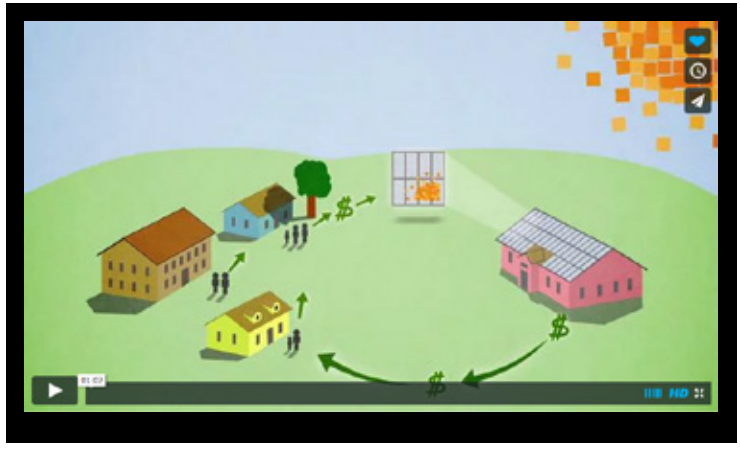


ReMade in Barona, a PSS set-up in the Barona district a Repairing platform based in Lope De Vega school, activating a team of skilled retired persons to repair various stuffs with a very low price. The platform: assess the re-pair team's qualification(mostly elderly and retired persons) qualification; put in contact with who needs repairing service; hosts specialised repair equipments.

https://www.youtube.com/watch?v=BZPXvCpVGSO

Figure 2.7
ReMade in Barona Project in Barona district, Designed by: Sara Hatef, Tutored by: Carlo Vezzoli, Claudio Di Benedetto

1.3. EXAMPLE OF RENEWABLE ENERGY VIDEOS



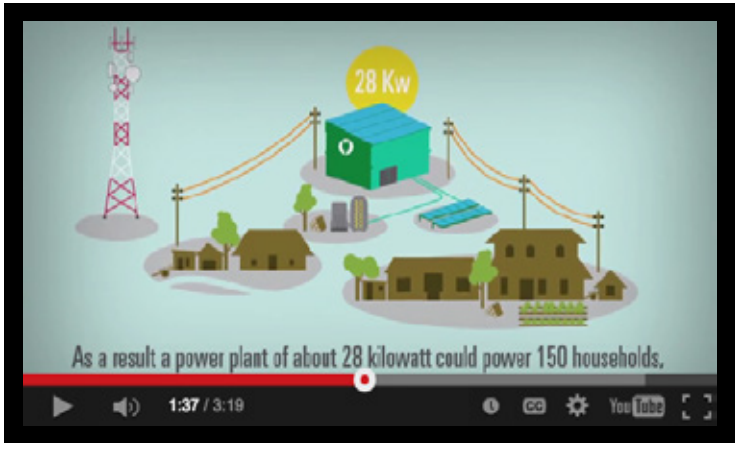
Together we all go solar.

By : Solar Mosaic
company : Solar Mosaic
License : Standard Vimeo License
Published on: April 15, 2011

https://vimeo.com/22459961

Visual Content
the first peer-to-peer lending platform for solar power, access to affordable solar loans, investors opportunities to invest in renewable power, and clean energy supporters the power to spread wealth from the sun to their communities.

Target Users
homeowners, investors, partners



Smart Power India: An Overview

By : The Rockefeller Foundation
company : The Rockefeller Foundation
License : Standard YouTube License
Published on: July 17, 2014

https://www.youtube.com/watch?v=KxUkwNW28PE#t=97

Visual Content

India has the world's largest population without electricity To address this problem, the Rockefeller Foundation piloted Smart Power India to help people gain access to affordable, reliable, and clean electricity.

Target Users

Indian household users

Clear Blue Technologies

By : MaRS Discovery District
company : Clear Blue Technologies
License : Non-commercial share alike
Published on: July 16, 2014

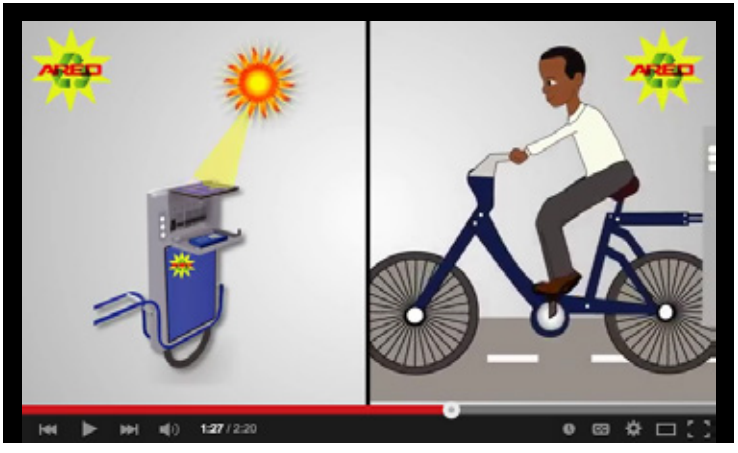
https://vimeo.com/100918986

Visual Content

solar panels and a wind turbine to power off-grid applications including streetlights, security solutions and mobile signage. The system is designed to easily integrate into a variety of products to deliver highly reliable off-grid alternatives.

Target Users

building owners



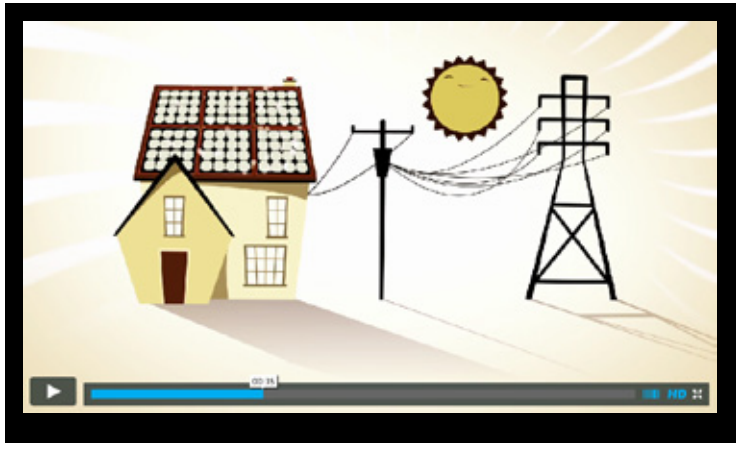
Mobile solar cell charger from African Renewable energy distributor

By : Henri nyakarund
company : ARED African Renewable Energy Distributor
License : Standard YouTube License
Published on: June 11, 2012

Visual Content
this is a Mobile Solar Cell Charger that will allow people on the go in urban and rural area from Africa to quickly charge their cell phones.

Target Users
small business owners, entrepreneurs

https://www.youtube.com/watch?v=Hth6W5-ZJSw&index=1&list=FLqf95U6rN2JTAemu-H24few



Green Hormigas

By : Gareth Jones
company : Green Hormigas
License : All audiences
Published on: October 29, 2011

https://vimeo.com/31291792

Visual Content
individuals can form groups, combine their buying power and invest together. Owners of existing solar power plants who wish to sell, use the same platform and are able to sell to the many investors.

Target Users
household users

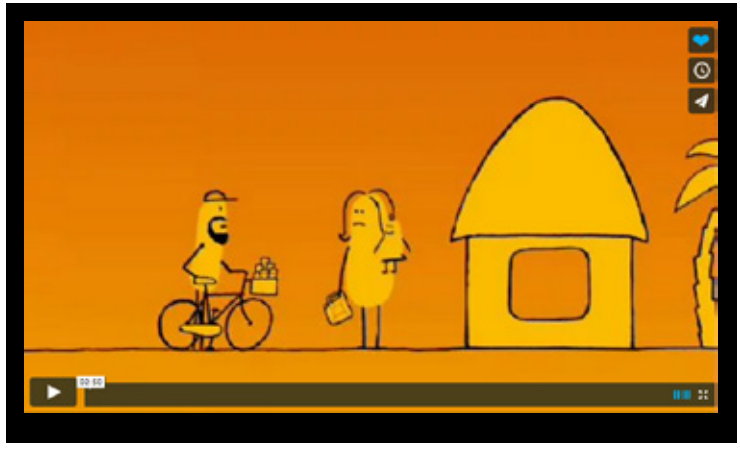
How Solar Works

By : groSolar
company : groSolar
License : Standard YouTube License
Published on: Octoberw 26, 2010

https://www.youtube.com/watch?v=bPE2pBUPjkA&index=57&list=WL

Visual Content
watch this brief video on how solar works in grid-tied residential applications. For all of your friends who've asked about solar, send them this link to explain, in simplicity, just how simple, solar really is.

Target Users
household users



Solar Mobile

By : Johan Klungel
company : -
License : Non-commercial share alike
Published on: July 22, 2011

https://vimeo.com/26778935

Visual Content
explaining the use of paying for your solar energy with your mobile phones, a project currently developed in several African countries by the client.

Target Users
local African people, solar company

2

ENERGY SUSTAINABILITY ORIENTED CONCEPT

MICRO GENERATOR/ ACCESSORIES OWNERSHIP

- Create a cooperative ownership model where the micro generator and the accessories (to produce and use energy) are owned by the community or group of people.

- Create a provider ownership model where the micro generator and the accessories (to produce and use energy) are all owned by the provider.

- Create a hybrid ownership model where the micro generator and the accessories (to produce and use energy) are owned by a partnership of companies.

ENERGY SYSTEM TYPES

- Create stand alone distributed energy systems

- Create mini-grids or local networks that connect distributed energy systems

- Create mini-grids or local networks that distribute energy produced from a decentralized energy system

- Create a decentralized energy centre (or recharge energy centre)

PSS BOUNDARIES

- Offer micro generator service
- Offer storage energy service
- Offer energy using products
- Create/offer a local mini grid service

CUSTOMER PURCHASE

- Payment based on the amount of energy (watt) used (post-paid / pre-paid)
- Payment based on the amount of time the energy is used (post-paid / pre-paid)
- Payment based on a periodical availability/access (post-paid / pre-paid)
- Hybrid type of payment Offer familiar method of payment/recharging such as scratch cards, mobile money, cell phone, GSM modem inside the device, etc.

SERVICES OFFERED IN THE PSS

- Include in the S.PSS offer the installation service (done by the provider)
- Provide in the S.PSS offer services during use such as maintenance, repairing, upgrading, substitution, etc.
- Offer in the S.PSS offer services of end-of life treatment

INITIAL INVESTMENT FINANCING

- Access to micro-credit
- Create a crowdfunding challenge
- Partnership with governmental bodies providing public support
- Partnership with private company institution as sponsor/donator
- Public-private partnership providing financial support

3

BEST PRACTICES

SOLAR-POWERED CAFÈ
South Africa

Provider : Solar Charge
Web Site : www.solarcharge.co.za
Adress : Alexandra Township, South Africa
Stage : Complete By 2012

A project is using solar power to bring internet to people in the township of alexandra. The connection center aims to bring low-cost access to basic services to the community of alexandra. The connection center is powered by the sun the solar powered operations mean that the equipment and the centre runs entirely off the electricity grid. This specific solar array setup allows for 14 hours of use per day with a five-day redundancy – meaning that even when there are cloudy or non-solar conditions for five days, the connection center can run for a further five days.

How much does it cost and how do users pay?
The internet is free for students, and subsidized for adults. It is the first internet shop in the township. This centre will allow the youth of alexandra to have uninterrupted access to the internet at very affordable rates as they will only pay for the time they spend on the internet as opposed to also paying for the data they access and generate. If they need office facilities like photocopying, faxing, or scanning, they can also do this at the center.

How is it maintained?
This project will be fully maintained by Solar Charge, will be donated to the Thusong Youth Centre and AlexFM radio station to be used to upgrade their own facilities and services offered to the community. Every container will have a highly-trained administrator who will be able to manage any problems that may arise. Should there be a need; solar charge also has the necessary technicians on hand to ensure connectivity. Various security features have been installed into the container, including theft-proof solar panels, sufficient battery power to last five days in the case of inclement weather, a cashless risk free trading environment, and a cash-in-transit provider to manage cash flow.

Eco-Efficiency Environmental Characteristics:
The amount of co2 reduction generated through the project activities is estimated to be 4,800 kg co2 /year. The potential further co2 reduction should all the solar home systems across the country be repaired is approximately 12,500 t co2 /year.

Eco-Efficiency Socio-Ethical Characteristics :

The center will benefit members of this community through providing job opportunities, reducing crime, and saving community costs. An uncapped Internet data line will give community members access to the Internet, where education development and job applications and be made, amongst many other services. Some of the features and benefits of this social investment project include an educational upliftment, sustainable job creation whilst at the same time providing for the creation of monthly recurring revenue generated from the sale of products and services processed through the Easy Pay Kiosk (prepaid airtime, prepaid electricity, EFT's), advertising, as well as from other facilities offered E.G. cell phone charging, photocopying, scanning and faxing. The container is in itself also a potential entrepreneurial venture, as they can be produced for people who would like to own their own business but have the details taken care of for them.

Sustainable Product Service System Key Characteristic

TYPE OF RENEWABLE ENERGY

SOLAR | WIND | HYDRO | BIOMASS

TYPE OF S.PSS

ADD VALUE LIFE CYCLE | FINAL RESULT | ENEABLING PLATFORM

TYPE OF END USE

HOUSEHOLD | BUSINESSS | COMMUNITY | OTHERS

OWNERSHIP OF MICRO GEN. AND ENERGY USING PRODUCT

CUSTOMER | COOPERATIVE | PROVIDER | HYBRID

TYPE OF ENERGY SYSTEM

LOCAL MINI GRID | NO GRID

PSS BOUNDARIES

MICRO GENERATOR | MINI-GRID | ENERGY USING PRODUCT

TYPE OF PAYMENT (FOR CUSTOMER)

PAY-PER TIME | PAY-PER USE | PAY-PER PERIOD | HYBRID

TYPE OF SERVICES INCLUDED IN THE PSS

INSTALLATION | SERVICE DURING USE | END-OF-LIFE TREATMENT

TYPE OF INITIAL INVESTMENT FINANCING

PURE BUSINESS | PUBLIC(GOV) | DONATION | HYBRID

ENERGY SHOPS
Namibia

Supplier :	Desert Research Foundation of Namibia
Web site:	www.drfn.org.na
Adress:	Alexandra Township, South Africa
Stage:	2009-2010 (Complete)

In Namibia, over 60% of the population does not have access to grid electricity, which is hindering the country's economic and societal growth. For off-grid regions, the establishment of "Energy Shops" can provide basic energy services, foster renewable energy technologies and enhance small-scale business opportunities

How much does it cost and how do users pay?
Each solar system costs around 1300€. In this demonstration project, the selected entrepreneurs received the solar system for free, after they had submitted an energy profile of their region and attended a business management course. They were also required to submit monthly financial records to DRFN for monitoring purposes. With a 5% fixed yearly interest rate, the entrepreneurs would be able to repay the system after five years or less, assuming that they could afford to repay 18 ¤ per month. However, not all shops generated this amount on PV services. The shops with lower income were given advice on how to improve their business.

How is it maintained?
The system has the capacity to charge ten mobile phones at once. In addition, the shops were equipped with a hair clipper, which can run for two hours a day, two wired lights, each with an operation time of three hours per day, and two portable LED lanterns. The systems were designed to be plug-and-play and, therefore, were easily installed in the shops. The participants were technically trained in the operation of the system.

Eco-Efficiency Environmental Characteristics:
By using solar energy for charging mobile phones and other devices, less fossil fuel based electricity is used, with the result that the CO2 emissions are reduced by around 1,500 kg per year. The reduction in the use of kerosene lamps should also mean that there is a positive impact on health. The only negative environmental impacts are related to the production and later disposal of the solar cells and batteries.

Eco-Efficiency Socio-Ethical Characteristics :

The Energy Shops offer business opportunities for the entrepreneurs and improve access to energy services for people with no grid connection. As the systems were purchased from local suppliers, the project also gave a boost to the local market for PV systems. However, in some communities, the Energy Shops had local business competitors, which resulted in envy. The access to charging services also influenced other services provided by the entrepreneurs. For example, a small bar run by one entrepreneur was able to extend its opening hours thanks to improved lighting, which both influenced the social life of the community and, simultaneously, improved the entrepreneur's profits from the solar charging

Sustainable Product Service System Key Characteristic

TYPE OF RENEWABLE ENERGY

SOLAR	WIND	HYDRO	BIOMASS

TYPE OF S.PSS

ADD VALUE LIFE CYCLE	FINAL RESULT	ENEABLING PLATFORM
	B2C	B2B

TYPE OF END USE

HOUSEHOLD	BUSINESSS	COMMUNITY	OTHERS
		B2C	

OWNERSHIP OF MICRO GEN. AND ENERGY USING PRODUCT

CUSTOMER	COOPERATIVE	PROVIDER	HYBRID
		B2C	

TYPE OF ENERGY SYSTEM

LOCAL MINI GRID	NO GRID
	B2C

PSS BOUNDARIES

MICRO GENERATOR	MINI-GRID	ENERGY USING PRODUCT
		B2C

TYPE OF PAYMENT (FOR CUSTOMER)

PAY-PER WATT	PAY-PER USE	PAY-PER PERIOD	HYBRID
	B2C	B2B	

TYPE OF SERVICES INCLUDED IN THE PSS

INSTALLATION	SERVICE DURING USE	END-OF-LIFE TREATMENT
B2B	B2B	

TYPE OF INITIAL INVESTMENT FINANCING

PURE BUSINESS	PUBLIC(GOV)	DONATION	HYBRID
		B2C	

SOLAR HOME SYSTEM REPAIR
Thailand

Supplier: Border Green Energy Team (BGET)
Web site: www.bget.org
Adress: Tak Province, Thailand
Stage: 2011-2012 (Complete)

Although the Ministry of Energy aims to increase the share of renewable energy, these technologies are too expensive for most rural communities. In 2004, the Thai government decided to subsidize and install 200,000 solar home systems in off- grid communities. Although this initiative provided solar power to many rural homes, the United Nations Development Programme discovered that only a few years later over 80% of these systems were no longer working. The main reasons for this situation were the use of low quality materials and the failure of the government to develop a long- term maintenance plan.

How much does it cost and how do users pay?
To provide the rural low-income households with the financial means to pay for the required repairs and maintenance a micro- loan model was developed. This micro- loan model provides various options for the households to make repayments over a two- year period. The average cost of restoring a single solar home system was estimated to be 440 €. Depending on the repairs required, household had to pay between 24 € and 95 € by the end of the first and second years. By the end of two years, the end users will own the systems and will have the option to extend the maintenance service by paying a yearly fee.

How is it maintained?
In cooperation with the project team the trained local technician carried out repairs to the existing systems. The users had to pay an agreed fee so that the repair and installation service could become a financially independent social enterprise. In addition to the training received by the technician, the end users also received customer orientation on proper product use and basic system maintenance training.

Eco-Efficiency Environmental Characteristics:
The potential further CO2 reduction should all the solar home systems across the country be repaired is approximately

12,500 tons CO2 /year.

Eco-Efficiency Socio-Ethical Characteristics:

The support of the local governments was very important for the community members. In the end they were confident enough to sign up for the solar system restoration and to agree to pay for the equipment and maintenance. In terms of employment, one villager was hired as full- time local technician. He is in charge of the system monthly check-up, fee collection and equipment repair or replacement. He will continue working during the rainy season when the roads are impassable and no external service providers or technicians can access the villages. Another positive effect of the project is that the 76 families who participated benefit from improved lightning. This means that the children in these households receive better lighting to do schoolwork and the women are also able to do housework and other income generating activities.

Sustainable Product Service System Key Characteristic

TYPE OF RENEWABLE ENERGY

SOLAR | WIND | HYDRO | BIOMASS

TYPE OF S.PSS

ADD VALUE LIFE CYCLE | FINAL RESULT | ENEABLING PLATFORM

TYPE OF END USE

HOUSEHOLD | BUSINESSS | COMMUNITY | OTHERS

OWNERSHIP OF MICRO GEN. AND ENERGY USING PRODUCT

CUSTOMER | COOPERATIVE | PROVIDER | HYBRID

TYPE OF ENERGY SYSTEM

LOCAL MINI GRID | NO GRID

PSS BOUNDARIES

MICRO GENERATOR | MINI-GRID | ENERGY USING PRODUCT

TYPE OF PAYMENT (FOR CUSTOMER)

PAY-PER TIME | PAY-PER USE | PAY-PER PERIOD | HYBRID

TYPE OF SERVICES INCLUDED IN THE PSS

INSTALLATION | SERVICE DURING USE | END-OF-LIFE TREATMENT

TYPE OF INITIAL INVESTMENT FINANCING

PURE BUSINESS | PUBLIC(GOV) | DONATION | HYBRID

THE SUN SHINES FOR ALL
Brazil

Supplier:	IDEAAS (Fabio Luiz de Oliveira Rosa)
Email:	fabrosa@terra.com.br
Adress:	Porto Alegre, Brazil
Stage:	2011 (Complete)

The Sun Shines for All (TSSFA) provide affordable energy solutions to a percentage of Brazilians people that live primarily in rural and off-grid communities who does not have access to electricity. TSSFA developed essential photovoltaic solar home system that provide customers with what they need and want. In fact instead of simply selling solar panels, batteries or other input products, TSSFA leases a complete package that provide customers with the service of electricity.

How much does it cost and how do users pay?
The product mix of the TSSFA is based on a well develop market research about what its target currently spending on energy sources. The kit that could be rented are three, the basic one it is leased for 8¤ /month, kits 2 and 3 rent for 13¤ and 19¤ respectively and come with more lights, outlets and wattage. Solar home kits include the hardware needed to generate energy and product that use the electricity (light bulb).

How is it maintained?
Instead of bringing in people from outside, Rosa and his staff get to know a community and identify people in that community to work with who have influence and/or are respected businesspeople. These become the local contacts for the user. They do installation, take care of problems, and collect fees. This is an important point, because in rural communities, people tend to know each other, and trust is essential. This approach also helps to overcome political opposition at the local level and benefits the community by putting the money people pay back into their own community.

Eco-Efficiency Environmental Characteristics:
It has been estimated that providing solar energy to 12,900 families would save 9 million litres of kerosene, 4.6 million kilos of liquefied petroleum gas, 9.3 million radio batteries and 23.2 million litres of diesel fuel. This help to reduce carbon emissions and impact on global warming. Moreover

all the device are leased, this means that the responsibility for the disposalis on the producer, that ismore capable of managing proper disposal than the costumer.

Eco-Efficiency Socio-Ethical Characteristics:

Thanks to the access to electricity people are more likely to stay in they villages, and helps reduce the massive exodus to Brazil's largest cities of income generation. Moreover, solar powered electricity removes the need for dangerous and unhealthy on non-renewable forms of energy such as kerosene and candles. Also having access to electricity encourages people to continue to improve their homes and their communities.

Sustainable Product Service System Key Characteristic

TYPE OF RENEWABLE ENERGY

SOLAR | WIND | HYDRO | BIOMASS

TYPE OF S.PSS

ADD VALUE LIFE CYCLE | FINAL RESULT | ENEABLING PLATFORM

TYPE OF END USE

HOUSEHOLD | BUSINESSS | COMMUNITY | OTHERS

OWNERSHIP OF MICRO GEN. AND ENERGY USING PRODUCT

CUSTOMER | COOPERATIVE | PROVIDER | HYBRID

TYPE OF ENERGY SYSTEM

LOCAL MINI GRID | NO GRID

PSS BOUNDARIES

MICRO GENERATOR | MINI-GRID | ENERGY USING PRODUCT

TYPE OF PAYMENT (FOR CUSTOMER)

PAY-PER TIME | PAY-PER USE | PAY-PER PERIOD | HYBRID

TYPE OF SERVICES INCLUDED IN THE PSS

INSTALLATION | SERVICE DURING USE | END-OF-LIFE TREATMENT

TYPE OF INITIAL INVESTMENT FINANCING

PURE BUSINESS | PUBLIC(GOV) | DONATION | HYBRID

INDIGO 'PAY-AS-YOU-GO' SOLAR
Kenya

Supplier:	Azuri Technologies and Eight 19's
Website:	www.azuri-technologies.com/indigo
Adress:	Kenya, Uganda, South Sudan
Stage:	2012 (Complete)

Eight19, has applied a common mobile phone business model to make solar energy affordable for rural Kenyans. Using a pay-as-yougo platform known as IndiGo, users can purchase a 3-watt solar panel, battery, two LED lamps, phone
charging unit, and module for only $10. Customers then buy scratch cards from local vendors that cost about $1 and allow access to electricity for a week when dialled into the IndiGo system. The power generated from these solar panels provides nearly eight hours of light each evening and supports mobile phone charging.

How much does it cost and how do users pay?
Using a pay-as-yougo platform known as IndiGo, users can purchase a 3-watt solar panel, battery, two LED lamps, phone charging unit, and module for only 8¤ Customers then buy scratchcards from local vendors that cost about $1 and allow access to electricity for a week when dialled into the IndiGo system. The power generated from these solar panels provides nearly eight hours of light each evening and supports mobile phone charging. Indigo has a transformational impact from day one. In Kenya, Indigo deployments are so cost-effective
that users spend half as much on their Indigo solutions that they previously did on kerosene.

How is it maintained?
Indigo solar offers to houses and small businesses in off-grid slums/rural contexts offering solar home systems,inverter, and energy using products based on initial fee in paying per time. After completing payments (e.g.18 months), users own the entire system and can decide to upgrade dre system. Installation included in the initial fee.

Eco-Efficiency Environmental Characteristics:
The most diffuse way to have energy is through kerosene, this brings many problems with health and environment due to the toxic emission, it is clear that the substitution

of this energy source with a clean one, the solar power indeed, can bring only advantages on both sides.

Eco-Efficiency Socio-Ethical Characteristics:

The impact of Indigo is felt by thewhole family but in particular by women to traditionally carry the responsibility for both household tasks and for childcare. Key benefits included extend the working day by typically three hours; more time to learn, earn and engage in family activities; eliminating harmful emissions caused by burning kerosene and problems associated with smoke inhalation; no longer limited by availability of kerosene – access to the "permanent light"; save time on trips to the market for mobile phone charging; children extend their study day often by 2 hours or more per night;

Sustainable Product Service System Key Characteristic

TYPE OF RENEWABLE ENERGY

SOLAR | WIND | HYDRO | BIOMASS

TYPE OF S.PSS

ADD VALUE LIFE CYCLE | FINAL RESULT | ENEABLING PLATFORM

TYPE OF END USE

HOUSEHOLD | BUSINESSS | COMMUNITY | OTHERS

OWNERSHIP OF MICRO GEN. AND ENERGY USING PRODUCT

CUSTOMER | COOPERATIVE | PROVIDER | HYBRID

TYPE OF ENERGY SYSTEM

LOCAL MINI GRID | NO GRID

PSS BOUNDARIES

MICRO GENERATOR | MINI-GRID | ENERGY USING PRODUCT

TYPE OF PAYMENT (FOR CUSTOMER)

PAY-PER TIME | PAY-PER USE | PAY-PER PERIOD | HYBRID

TYPE OF SERVICES INCLUDED IN THE PSS

INSTALLATION | SERVICE DURING USE | END-OF-LIFE TREATMENT

TYPE OF INITIAL INVESTMENT FINANCING

PURE BUSINESS | PUBLIC(GOV) | DONATION | HYBRID

SMALL WIND POWER GENERATION
Peru

Supplier	Soluciones Prácticas
Web site:	www.solucionespracticas.org.pe
Adress:	Village El Alumbre, Peru
Stage:	2007-2009 (Complete)

The project was designed to electrify an entire rural community including a school and a medical centre. The selection of the village El Alumbre was based on the favourable wind potential and the willingness of the authorities and the population to contribute to the project.

How much does it cost and how do users pay?
The estimated cost for the individual wind turbines was as high as 400€ (for the 100W turbines) and 1200€ (for the two 500W turbines at the school and the medical centre). The families now spend less on average on energy than they did prior to the project. They used to spend more than 4€ a month for energy from kerosene or candles etc.; now, each family pays 2€ a month for a better quality service and for greater periods of light.

How is it maintained?
Another important step for the success of the project was the training of users and technicians. Since the end of the project implementation period, the District Municipality has legally owned the system and the trained technician has been in charge of the technical and administrative operations. Together with the Community Electrification Committee, the users and the Control Unit, the technician and the District Municipality also belong to the group of five stakeholders. This local management model ensures the sustainability of the project, as it takes into account the social relationships that exist within the community.

Eco-Efficiency Environmental Characteristics:
The use of the wind power generating systems has replaced the former use of conventional energy such as kerosene, candles and batteries. In order to save energy, efficient light bulbs have been installed in most houses and in the school. The total volume of power used in the village now amounts to 2737 kW/year, which is a reduction of 38.32 kg CO2 /year. The consumption is 43% less than estimated upfront, as the families consume less electricity than the predicted amount

of 400W/day/family. In future, the energy consumption is expected to increase – but only to a limited extent

Eco-Efficiency Socio-Ethical Characteristics:

As a result of the access to electricity, several small businesses such as two radio broadcasting stations, a sweater-making business and a cheese factory have been established. Furthermore, access to electricity has enabled the local population to use modern information and communication technologies. As an example, the percentage of the local population using mobile phones has increased from 5% to 95%, due to the access to electricity.

Sustainable Product Service System Key Characteristic

TYPE OF RENEWABLE ENERGY

SOLAR | WIND | HYDRO | BIOMASS

TYPE OF S.PSS

ADD VALUE LIFE CYCLE | FINAL RESULT | ENEABLING PLATFORM

TYPE OF END USE

HOUSEHOLD | BUSINESSS | COMMUNITY | OTHERS

OWNERSHIP OF MICRO GEN. AND ENERGY USING PRODUCT

CUSTOMER | COOPERATIVE | PROVIDER | HYBRID

TYPE OF ENERGY SYSTEM

LOCAL MINI GRID | NO GRID

PSS BOUNDARIES

MICRO GENERATOR | MINI-GRID | ENERGY USING PRODUCT

TYPE OF PAYMENT (FOR CUSTOMER)

PAY-PER WATT | PAY-PER USE | PAY-PER PERIOD | HYBRID

TYPE OF SERVICES INCLUDED IN THE PSS

INSTALLATION | SERVICE DURING USE | END-OF-LIFE TREATMENT

TYPE OF INITIAL INVESTMENT FINANCING

PURE BUSINESS | PUBLIC(GOV) | DONATION | HYBRID

MICRO-HYDRO PLANTS
Brazil

Supplier : Soluciones Prácticas
Web site: www.solucionespracticas.org.pe
Adress: Village El Alumbre, Peru
Stage: 2007-2009 (Complete)

Hydro schemes use turbines to generate mechanical power from falling water. This can be used directly to drive machinery or coupled to a generator to produce electrical power. All are 'run of the river' plants, which use a low dam or weir to divert water from the river to the turbine.

How much does it cost and how do users pay?
Customers pay for their electricity usage based on the meter reading and the tariff that is agreed with CRELUZ. The cooperative has offices in many urban centres, and various shops and pay points have been authorised as collecting agencies where customers can go to pay. CRELUZ sells electricity to its members at similar prices to other electricity distribution companies. The average price including tax is 0.16€ per kWh There is a sliding scale of tariffs, whereby larger, wealthier users pay more per kWh. Poorer families get a subsidised price of up to 64% discount, and about 600 families receive free electricity through the cooperative's social programmes.

How is it maintained?
The CRELUZ engineers train operators on the technical aspects of the hydro plant. Employees are also given training on the environmental component of their work, with strict rules to follow in this respect. Each member is given a free phone number to call that is available 24 hours a day in order to report problems with the power supply. CRELUZ has a team of engineers who come out to repair line faults. Generating cheaper electricity through its hydro plants has helped CRELUZ to make an operating profit each year. This has been used to expand the distribution network, build more hydro plants, keep the tariff low and reduce it for poorer customers, and also for social activities within the local communities

Eco-Efficiency Environmental Characteristics:

The hydro plants were designed to minimise local environmental impact, with small dams, fish passes and flood control systems. In addition, each canal that diverts water from the river has a trash rack to collect floating debris before the water enters the penstock pipes. Plastic bottles are then collected and recycled, whilst organic debris is used to make compost.

Eco-Efficiency Socio-Ethical Characteristics:

The electricity supply in the communities now served by CRELUZ was very variable in the past, and many families were not connected to the grid. The people living in these communities were often forced to migrate to the cities due to limited income generating opportunities. The communities now have access to better quality and more reliable electricity, which allows them to have lights, TV, fridges and better lifestyles.

Sustainable Product Service System Key Characteristic

TYPE OF RENEWABLE ENERGY

SOLAR | WIND | **HYDRO** | BIOMASS

TYPE OF S.PSS

ADD VALUE LIFE CYCLE | **FINAL RESULT** | ENEABLING PLATFORM

TYPE OF END USE

HOUSEHOLD | **BUSINESSS** | **COMMUNITY** | OTHERS

OWNERSHIP OF MICRO GEN. AND ENERGY USING PRODUCT

CUSTOMER | COOPERATIVE | **PROVIDER** | HYBRID

TYPE OF ENERGY SYSTEM

LOCAL MINI GRID | NO GRID

PSS BOUNDARIES

MICRO GENERATOR | **MINI-GRID** | **ENERGY USING PRODUCT**

TYPE OF PAYMENT (FOR CUSTOMER)

PAY-PER TIME | PAY-PER USE | PAY-PER PERIOD | HYBRID

TYPE OF SERVICES INCLUDED IN THE PSS

INSTALLATION | **SERVICE DURING USE** | **END-OF-LIFE TREATMENT**

TYPE OF INITIAL INVESTMENT FINANCING

PURE BUSINESS | **PUBLIC(GOV)** | **DONATION** | HYBRID

DOMESTIC BIOGAS
Nepal

Supplier :	Biogas Sector Partnership (BSP)
Web site:	www.bspnepal.org.np
Adress:	Sarangot near Pokhar, Nepal
Stage:	2005 (Complete)

Biogas systems take organic material such as manure into an air-tight tank, where bacteria break down the material anaerobically (without oxygen) and release biogas The gas is piped to the kitchen inside the house, where it is used for cooking on specially-designed burners, and sometimes for lighting as well. The gas pressure pushes digested residue out from the base of the digester into a reservoir tank, from where it is collected and used as fertiliser.

How much does it cost and how do users pay?
The subsidy programme managed by the BSP is designed to correct this difference by providing higher subsidies to families in more remote locations. About one third of this is paid in kind, through the family providing labour and materials. The remaining US$160 is a significant amount of money in Nepal, but people are willing to pay for the benefits of biogas. Also, over 80 banks and micro-finance organisations in Nepal will provide loans for biogas plants because they are regarded as a safe investment. Most families pay back their loan within about 18 months: those who previously purchased fuelwood will have saved more than the cost of the biogas plant within this time.

How is it maintained?
One of the main roles of the BSP is to provide training and quality control. By 2005, over 6,000 people had been trained in plant construction, and all users had been trained in operating biogas plants and carrying out minor repairs. In 2005, installations were carried out by about 61 private construction companies, which were monitored and accredited by BSP. The cost of the biogas plant includes a three-year guarantee period, during which time free maintenance has to be provided by the installation company another incentive to install high-quality plants at the start.

Eco-Efficiency Environmental Characteristics:
Biogas plants has reduced the consumption of fuel wood rural household uses for cooking. However there is a small

net increase in methane emission, because the unburned methane from cooking and minor leaks is slightly greater than the avoided emission of methane from manure disposal.

Eco-Efficiency Socio-Ethical Characteristics:

Households with biogas plants save on average three hours per day. This time saving has a huge impact on the lives of women and girls, who use the extra time for income generation or for education. Fuelwood and, in particular, cattle dung-cakes are very polluting fuels when burned indoors on open fires. Women and children are exposed to high levels of carbon monoxide, particulates and unburned hydrocarbons. Biogas produces very low emissions and thus brings enormous health benefits and also leaves the kitchen much cleaner. Biogas stoves are very easy to control and there is less risk of accidental burns or fires because the stove is turned off as soon as cooking has finished.

Sustainable Product Service System Key Characteristic

TYPE OF RENEWABLE ENERGY

SOLAR | WIND | HYDRO | BIOMASS

TYPE OF S.PSS

ADD VALUE LIFE CYCLE | FINAL RESULT | ENEABLING PLATFORM

TYPE OF END USE

HOUSEHOLD | BUSINESSS | COMMUNITY | OTHERS

OWNERSHIP OF MICRO GEN. AND ENERGY USING PRODUCT

CUSTOMER | COOPERATIVE | PROVIDER | HYBRID

TYPE OF ENERGY SYSTEM

LOCAL MINI GRID | NO GRID

PSS BOUNDARIES

MICRO GENERATOR | MINI-GRID | ENERGY USING PRODUCT

TYPE OF PAYMENT (FOR CUSTOMER)

PAY-PER TIME | PAY-PER USE | PAY-PER PERIOD | HYBRID

TYPE OF SERVICES INCLUDED IN THE PSS

INSTALLATION | SERVICE DURING USE | END-OF-LIFE TREATMENT

TYPE OF INITIAL INVESTMENT FINANCING

PURE BUSINESS | PUBLIC(GOV) | DONATION | HYBRID

SCHOOL COOKING STOVE
India

Supplier : Nishant Bioenergy Consultancy
Web site: www.solucionespracticas.org.pe
Adress: Zirakpur, Chandigarh Punjab, India
Stage: 2005-2010 (Complete)

India has many schools and other institutions that provide meals for large numbers ofpeople. Liquified Petroleum Gas (LPG) is widely used for cooking, and is currently subsidised by the Government. At the same time crop waste which cannot be used for animal fodder is often burned in the fields, in order to allow a second crop to be planted quickly. However this waste can be compressed into briquettes and used as a fuel. Nishant Bioenergy developed the Sanjha Chulha (combined stove) so that institutions could save money using briquettes rather than LPG for cooking.

How much does it cost and how do users pay?
The stove costs about 2,438¤ and users must pay this cost, plus the cost of the briquettes, in full. Many residential schools in India are providing education to poor students: they do not have large capital budgets and they are not allowed to take out bank loans. Nishant Bioenergy therefore provides credit, so that users pay in instalments from the savings they make in their fuel costs.

These payments are collected over a period of about 18 months, to allow for school holidays.

How is it maintained?
Staff from Nishant Bioenergy install each stove and provide three days' training for users. During this training period, briquette use is monitored and the stove's running cost estimated and compared with the previous cost of LPG. This gives users the confidence that the monthly payments are affordable. Nishant offers a maintenance contract for 135¤ per year. The stoves installed to date have worked very reliably.

Eco-Efficiency Environmental Characteristics:
Using briquettes instead of LPG gives both local and global environmental benefits. The residues used for briquettes would normally be burned in the field to allow a second crop to be planted. Briquetting avoids the local pollution and fire risk of burning in this way There are some concerns

about using agricultural residues in domestic-scale stoves, because they tend to produce more particulates and gaseous pollutants than wood or LPG, particularly if the stoves are lit and extinguished several times during a day. However, the design of the Sanja Chulha and the fact that the stove is used for extended times ensures efficient, clean combustion. The electricity used to make the briquettes and run the fans produces an estimated 1 tonne/year of CO_2 , so the net annual saving is about 25 tonnes/year of CO_2 per stove.

Eco-Efficiency Socio-Ethical Characteristics:

The stoves are popular with schools. Cooks find them convenient to operate, they can use them for different types of cooking and the food tastes good.

Sustainable Product Service System Key Characteristic

TYPE OF RENEWABLE ENERGY

SOLAR | WIND | HYDRO | BIOMASS

TYPE OF S.PSS

ADD VALUE LIFE CYCLE | FINAL RESULT | ENEABLING PLATFORM

TYPE OF END USE

HOUSEHOLD | BUSINESSS | COMMUNITY | OTHERS

OWNERSHIP OF MICRO GEN. AND ENERGY USING PRODUCT

CUSTOMER | COOPERATIVE | PROVIDER | HYBRID

TYPE OF ENERGY SYSTEM

LOCAL MINI GRID | NO GRID

PSS BOUNDARIES

MICRO GENERATOR | MINI-GRID | ENERGY USING PRODUCT

TYPE OF PAYMENT (FOR CUSTOMER)

PAY-PER TIME | PAY-PER USE | PAY-PER PERIOD | HYBRID

TYPE OF SERVICES INCLUDED IN THE PSS

INSTALLATION | SERVICE DURING USE | END-OF-LIFE TREATMENT

TYPE OF INITIAL INVESTMENT FINANCING

PURE BUSINESS | PUBLIC(GOV) | DONATION | HYBRID

DRE MICRO GENERATOR

Solar Home Repair

Energy Shop

Micro-Hydro Plants

Small Wind Power

ENABLING PALTFORM

FULL SERVICE

Solar powered café

Domestic Biogas

The Sun Shines For All

School Cooking Stove

Indigo “pay-as-you-go” solar

DRE MICRO GENERATOR & ENERGY USING PRODUCT

Figure 2.8
Sustainability Design Orienting-Scenario from Best practices

4

STRATEGIES AND GUIDELINES S.PSS-ORIENTED DRE

Optimise DRE systems configuration

- Offer ***stand-alone*** Distributed Renewable Energy (DRE) systems for homes or business sites (especially to off-grid and isolated sites)
- Offer local ***mini-grids*** connecting DRE systems, to enable local energy surpluses sharing (especially for context with nearby energy consuming units)
- Offer DRE spots with ***multiple-recharging*** devices for local communities
- Offer ***decentralized*** renewable energy systems to locally supply energy throughout a mini-grid for homes and/or business sites
- Offer DRE system with ***connection*** to ***main-grid***, enabling homes, small business and local mini grids the selling/purchasing of energy

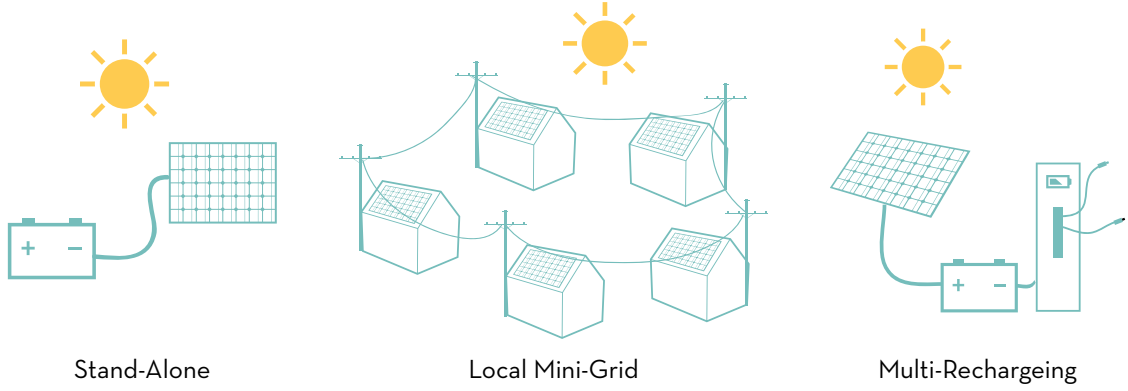


Figure 2.9
DRE System configuration of Stand-alone, Local mini-grid and Multi-recharging

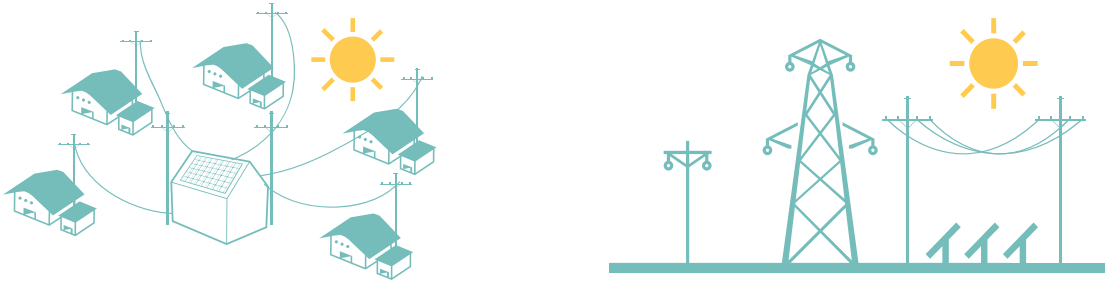


Figure 2.10
DRE System configuration of Decentrialized and Connecting main-grid.

Complement the DRE offer with life cycle services

- Complement the DRE offer, with (turnkey based) support services for the ***design*** and/or ***installation*** of its components (the micro generator, the storage, the inverter, the wiring, etc.)
- Complement the DRE offer, with (turnkey based) support services during use, i.e. ***maintenance, repairing and upgrading of its components***
- Complement the DRE offer, with (turnkey based) support services for ***the end-of life treatment of its components***
- Complement the DRE offer, with (turnkey based) support services for ***training/ information*** on design, installation, maintenance, repair and end of life treatment of its components

Offer ownerless DRE systems with full services

- ***The energy supplier*** (existing or newly established) complements the ***ownerless*** offer of the DRE system - ***micro generator*** eventually with some of its accessories (storage, inverter, wiring, etc.) and/or the mini-grid – with the offer of one or more ***life cycle*** support ***services***, i.e. installation, maintenance, repairing, upgrading and end-of life treatment.
- ***The micro generator producer*** complements the ***ownerless*** offer of the dre system, with the offer of one or more ***life cycle*** support ***services***, i.e. installation, maintenance, repairing, upgrading and end-of life treatment.
- ***A partnership*** composed by two or more among the energy supplier, the micro generator producer, the storages producer, the inverters producer, etc., Complements the ***ownerless full package*** offer of their products, with one or more ***life cycle*** support ***services***.

Offer ownerless DRE systems as enabling platform

- ***The energy supplier (existing or newly established)***

complements an ownerless offer of the dre system - micro generator eventually with some of its accessories (storage, inverter, wiring, etc.) And/or the mini-grid - with ***training/ information*** services to enable the customer to either ***design, install, maintain, repair*** and/ or ***upgrade*** one or more of the ***DRE components***

- ***The micro generator producer***

complements an ***ownerless*** offer of the ***micro generator*** - eventually with its accessories and/or the mini grid - with training/information services to enable the customer to either ***design, install, maintain, repair*** and/or ***upgrade*** the ***micro generator***

- ***The storage and/or the inverter, etc. producers***

complements an ***ownerless*** offer of their products with training/information services to enable the customer to either ***install, maintain, repair*** and/or ***upgrade their products***

- ***A partnership composed by two or more stakeholder among the energy supplier, the micro generators producer, the storages producer, the inverters producer, etc.***

complements an ***ownerless full package*** offer of their products with ***training/information*** services to enable the customer to either install, maintain, repair and/or upgrade them

Delinked payment form pure watt consumption (affordable costs)

- ***Pay x period,***

i.e. The cost is daily/weekly/monthly/yearly fixed

- ***Pay x time of access to energy,***

i.e. the cost is fixed per minutes/seconds of access to energy

- ***Pay x use/satisfaction unit of (energy using) product,***

i.e. the cost is fixed per product performance (e.g. km for a vehicle, washing cycles for washing machine)

- ***Payment based on hybrid***

pay x period, pay x time, pay x use modalities, apply for additional financial support from public administrations/entities, apply for additional financial support with micro-credit

- ***Financial private support (donation)***

Launch your proposal on existing platform for additional financial support via crowd-funding

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

- ***The energy supplier***

complement the offer of ownerless DRE system and its life cycle services, with the offer of energy using products (ownerless and/or complemented with life cycle services)

- ***The micro generator producer***

complement the offer of ownerless micro generator and its life cycle services, with the offer of energy using products

- ***An energy using product producer***

complement the offer of ownerless ***products*** and their life cycle services, with dre system offer

- ***A partnership composed by two or more stakeholders among the energy supplier***

the micro generators producer, the storages producer, the inverters producer, etc. And the energy using product producer, offer a full package of ownerless dre system and energy using products with their life cycle services

3.

THE DESIGN PROCESS

1

THE MSDS METHOD TO DESIGN THE SDOS

The MSDS (Method for System Design for Sustainability) method aims to support system innovation that developed and tested by DIS research unit and other European research center and companies. The Method is an adaptation of the MEPSS1 methodology, able to support and orient, in a multi-stakeholder visioning process, the design and development of Sustainable Product-Service System (PSS).

The phases of the followed method are Strategic analysis, Exploring Opportunities and Designing system concept. Firstly, we are focusing on the process of context analysis and the structure system through the best practices that determine priorities for the design intervention in the view of sustainability. The research of distributed renewable energy case studies are related to Eco-Efficiency environmental /social-ethical and sustainable key characteristic. Secondly is to generate ideas oriented toward sustainability and outline a sustainability oriented design scenario through the workshop in order to create visions, clusters of sustainable idea and individual ideas oriented towards sustainability toward social and environmental criteria by SDO toolkit. Lastly, we selected clusters and single ideas to develop system concepts in each vision from the polarities diagram are promising to the potential social, environmental and economic sustainability improvement.

For each phase will present the aim and processes of general structure of the MSDS methods to achieve the scenario.

	PROCESS	AIM	TOOLS
STRATEGIC ANALYSIS	· Understanding the context reference · Defining design priorities for sustainable solution · Analyzing cases of excellence for sustainability · Understanding S.PSS characteristic	To understand the stakeholder's interaction between providers and uses in term of the business process of the company and the system of involved.	· System map · Sustainability Design-Orienting toolkit (SDO) · Best practices
EXPLORING OPPORTUNITIES	· Sustainable ideas generation · Workshop for generating sustainable system idea · Drawing up sustainability design-orienting scenarios	to define a "catalogue" of strategic possibilities of intervention for significantly more eco-efficient model of distributes renewable energy in low and middle income (all) contexts. It has been generated and elaborated a promising sustainable design-orienting scenario.	· Polarity Diagram · Sustainability Design-Orienting toolkit (SDO) · Offering diagram

1.1. STRATEGIC ANALYSIS

First step of the design process has been the Strategic Analysis. The aim of the first part of the method is to collect and elaborate information necessary in order to facilitate the generation of sustainable product-service system ideas and scenarios. In particular four steps have been carried out

Understanding the context reference
The objective has been to acquire and elaborate information on the context, or rather the socio-ethical in low and middle-income contexts. The structure of the production and consumption system (the scope of intervention) is analyzed: who are providers (local government, NGOs, big and small private companies, and local institutions) or users (B2B; small and middle entrepreneur, B2C; final users) and what the relationships are between them.

Defining design priorities for sustainable solution
The objective has been to analyze the existing context from an environmental, socio-ethical and economic point of view in order to identify the de¬sign priorities. This operation is fundamental to steering the design process towards the solutions that are the most able to foster sustain¬ability.

Analyzing cases of excellence for sustainability (best practices)
The objective has been to analyze in detail cases of excellence that could act as a stimulus during the generation of ideas. The result will be a summary the offer in each case of interactions with the stakeholders, the offer providers what kind of the energy production and distributors, how does the PSS works and its sustainability characteristics in terms of social and environmental issues.

Understanding S.PSS characteristic

The objective has been to comprehend the main characteristic of sustainable product service system: what are the type of S.PSS; who is the ownership of the DRE service, DRE configuration, what is paid by the customers and the financing investment which are the key stakeholder and other involved actors

THE PROCESS

In Strategic analysis by using co-design tools can use it to describe the production and consumption system in the scope of the design intervention. Another relevant aspect investigated was the economic, environmental and social sustainability of the offer, and referred to the general sustainable ideas. The objective is to understand the stakeholder's interaction between providers and uses in term of the business process of the company and the system of involved. We started to collect information about renewable energy service and how the Sustainable Product-Service System applied to Distributer Renewable Energy in low-middle income context. All the case studies are presented in the first workshop before generate sustainable single ideas through SDO toolkit

THE TOOLS

To set the strategic analysis have been used the following co-design tools:

System map: to visualize the system structure of the offers indicating the actors involved and their interactions. It is basically a graphic representation showing: providers, users, material flow, labor performance, financial flow and information flow. It can be shown the organisation of the system (actors and roles) in a case study.

Sustainability Design-Orienting toolkit (SDO) to analysis the existing initiative in terms of environmental, economic and social-ethical sustainability and to define a priorities for action planning.

Best Practices To understanding the different typology of renewable energy (such as solar power, wind power, hydro power, biomass) in all contexts from business scale to local and communities in different countries around the world. As far as understanding the concept of S.PSS characteristic and environmental, economic and social-ethical sustainability

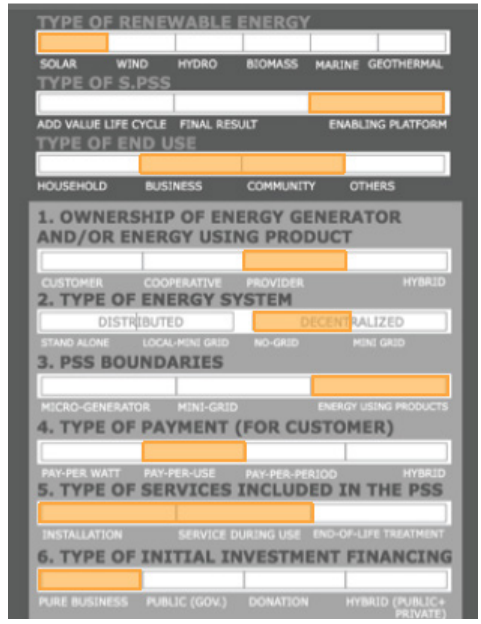


Figure 3.1
Sustainable PSS Key Characteristic of solar-powered café, Alexandra, South Africa

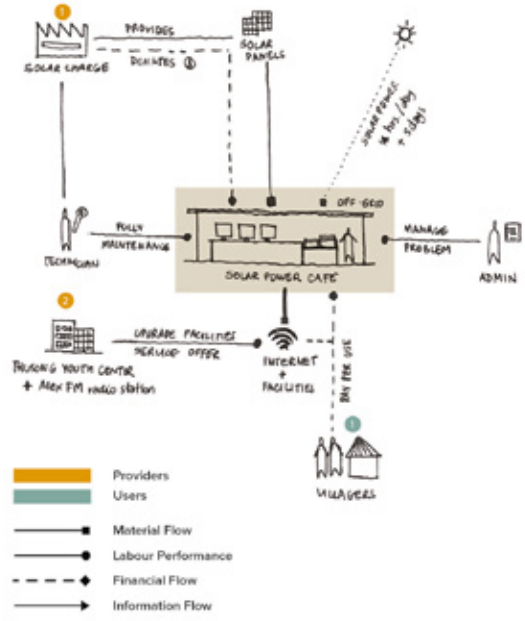


Figure 3.2
System map of solar-powered café, Alexandra, South Africa

1.2. EXPLORING OPPORTUNITIES

Second step of the design process has been the Exploring Opportunities. The aim has been, using all the information collected and elaborated in the previous phase, to define a "catalogue" of strategic possibilities of intervention for significantly more eco-efficient model of distributes renewable energy in low and middle income (all) contexts. It has been generated and elaborated a promising sustainable design-orienting scenario. In particular three main steps have been carried out:

Sustainable ideas generation
Two ideas generation workshops has been performed to generate a set of sustainable product-service system ideas applied to distributed renewable energy in any contexts.

Workshop for generating sustainable system idea
The idea generation has been orientated with workshop activities by using design criteria and guidelines Sustainability Design-Orienting toolkit (SDO)

Drawing up sustainability design-orienting scenarios
This process is to map out the ideas generated of DRE by using a purpose designed polarities that it is a diagram with two polarity axes (e.g. user participation: enabling platform-full service; offer boundaries: micro generator-micro generator and energy using product, customer type: B2B-B2C), on which itis possible to position and organise ideas. .

THE PROCESS

First Workshop (Milan, 2nd of July, 2014)

Sustainability Design-Orienting Scenario IDEAS GENERATION for each of the design sustainable energy environmental and social-ethical criteria of. The idea generation stages are suggested by SDO guidelines and best practices for any context and any satisfaction units (ideas boundaries are wider than only the energy system). The aim of such a workshop is to generate explorative and promising ideas on services and stakeholders interactions that lead to the design of a draft sustainability design orienting scenario: eco-efficient (Product-Service) System ideas and visions. The main steps are:

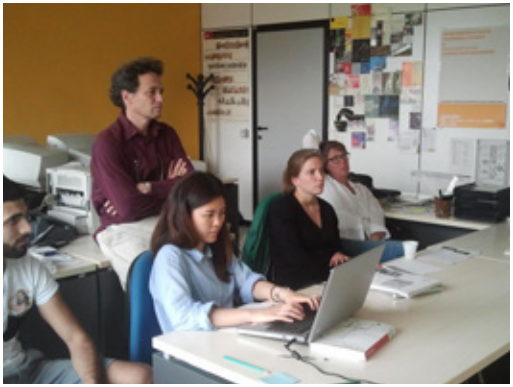
Best Practices

To understand the main idea of PSS; why the service is sustainability; what are the benefit of users and providers as the basic payment and analyzing the social and environmental characteristics of each case study in different typology of renewable energy and contexts?

Ideas generation

- Targeting *6 environmental sustainability criteria* (System life optimization, Transportation/ distribution reduction, Resource reduction, Waste minization/valorization, Conservation/ biocompatibility and Toxicity reduction)

-Targeting *6 social-ethical sustainability criteria* (Improve employment and working conditions, Improve equity and justice in relation to stakeholders, Enable a responsible and sustainable consumption, Favor/integrate weaker and marginalized strata, improve social cohesion and Empower/ valorize local resources)



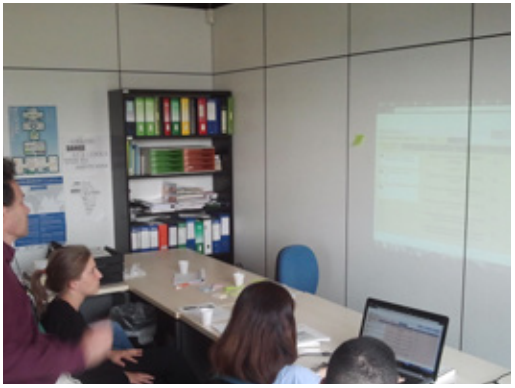
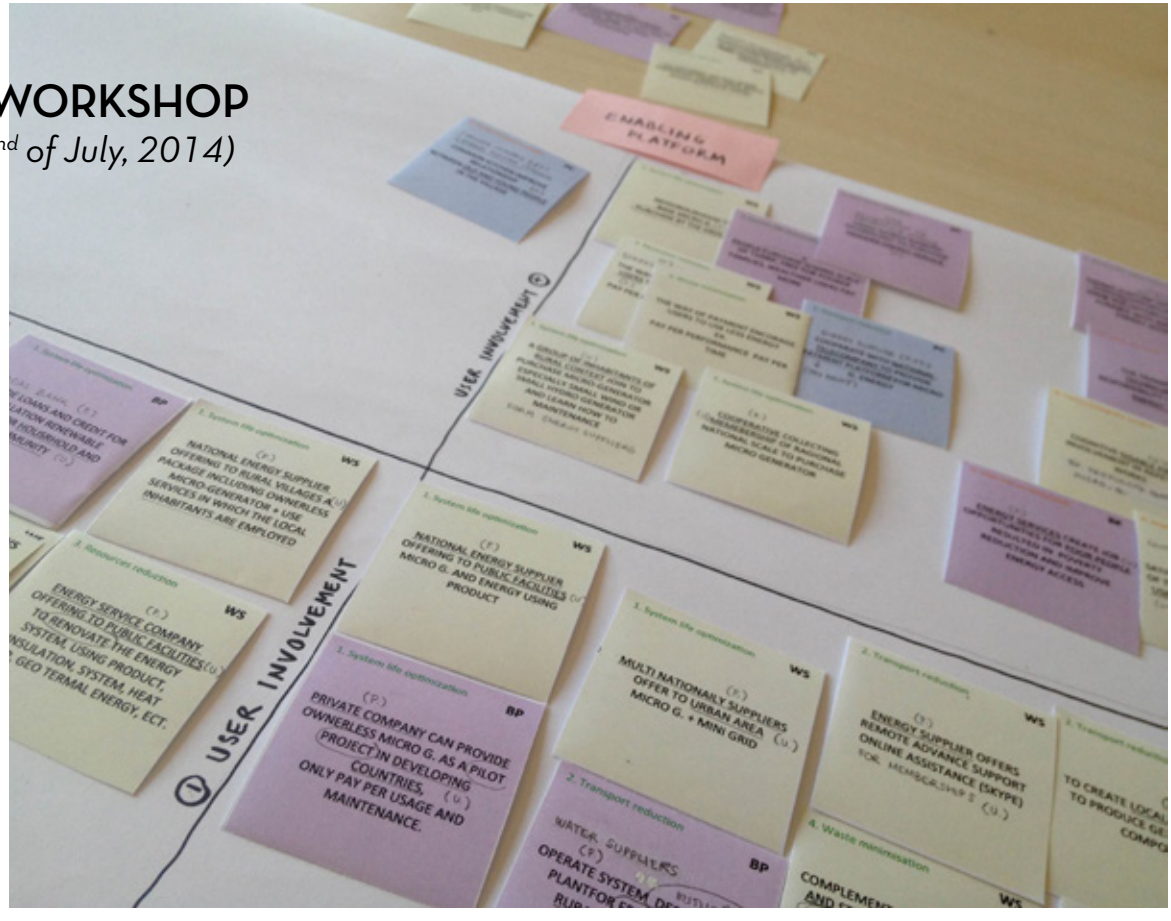


Figure 3.3
First workshop (Milan, 2nd of July, 2014) Sustainability Design-Orienting Scenario IDEAS GENERATION suggested by SDO guidelines and best practices

Figure 3.4
Sustainability Design-Orienting toolkit (SDO) for environmental and social-ethical sustainability concept

FIRST WORKSHOP

(Milan, 2nd of July, 2014)



Second Workshop (Milan, 21st of July, 2014)

Sustainability Design-Orienting Scenario IDEA POLARIZATION (re-generation) using two polarities highlighting PSS modalities main tools and supportive documents

The aim of such a workshop is to get the clustering of ideas and visions generated and aiming at identifying those worth exploring further, at their improvement and at new sustainable ideas generation.

The main steps are:

Single ideas Categorize the single draft ideas form idea generation; evaluation, improvement and re-generation.

Visions and ideas clusters evaluation, improvement, and new generation on the polarity diagram (the designing process to define and visualize what we call a sustainability design-orienting scenario)

THE TOOLS

To set the exploring opportunities phase have been used the following co-design tools:

Polarities diagram

A diagram constructed by crossing two polarities, one polarity shows a possible variation in the product-service system in two opposite directions (e.g. full service- enabling platform, B2B-B2C). The tool facilitates the positioning and organization of the ideas in the diagram; on the other it stimulates the generation of further ideas.

Sustainability Design-Orienting toolkit (SDO)

To analysis the existing initiative in terms of environmental, economic and social-ethical sustainability and to define a priorities for action planning.

Offering Diagram

A graphical representation of the offer provided by the system, illustrating the core function of S.PSS ideas and add value functions delivered to the customer and/or emd-user

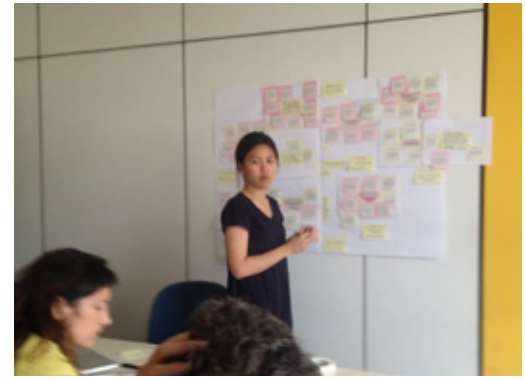
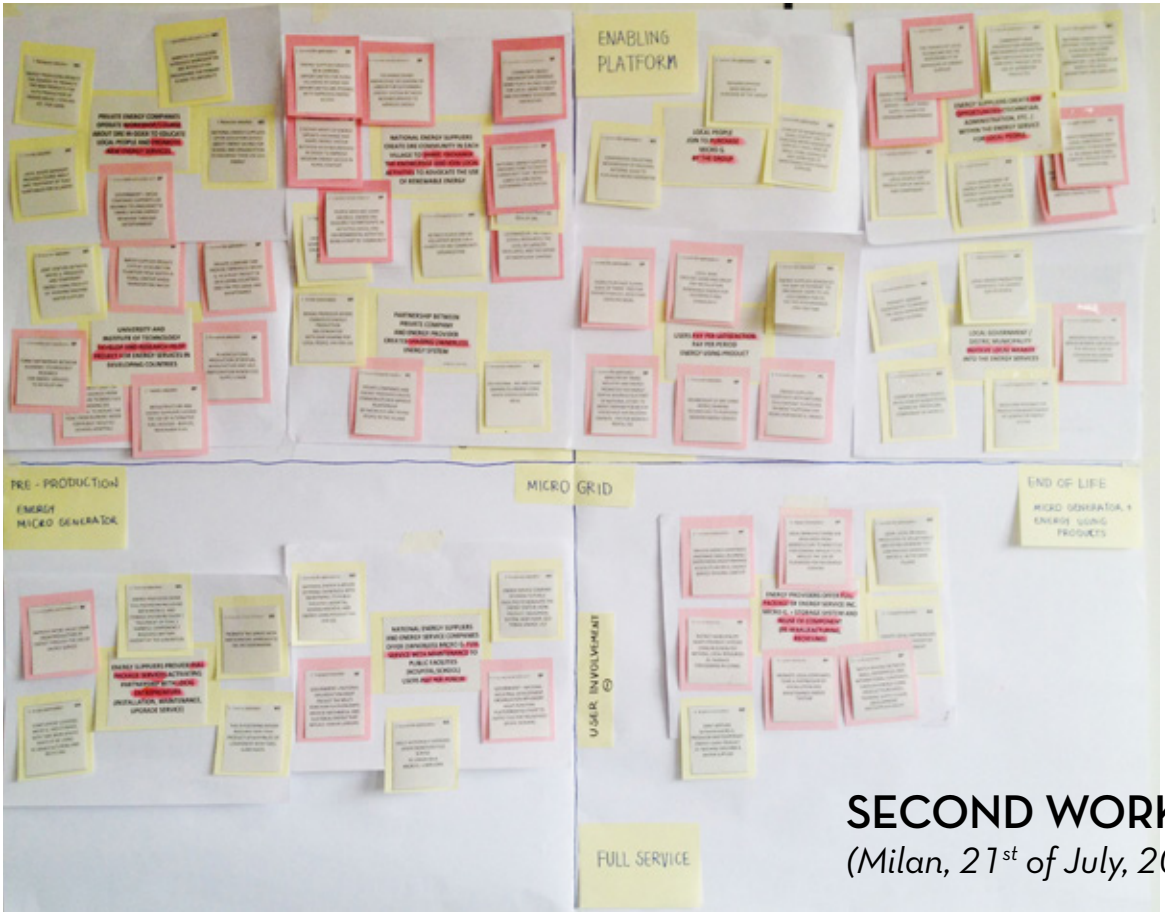


Figure 3.5
Second workshop (Milan, 21st of July, 2014) Sustainability Design-Orienting Scenario IDEA POLARIZATION (re-generation)

Figure 3.6
Sustainability Design-Orienting toolkit (SDO) for environmental and social-ethical sustainability concept



SECOND WORKSHOP

(Milan, 21st of July, 2014)

2

SUSTAINABLE DESIGN ORIENTED SCENARIO (SDOS)

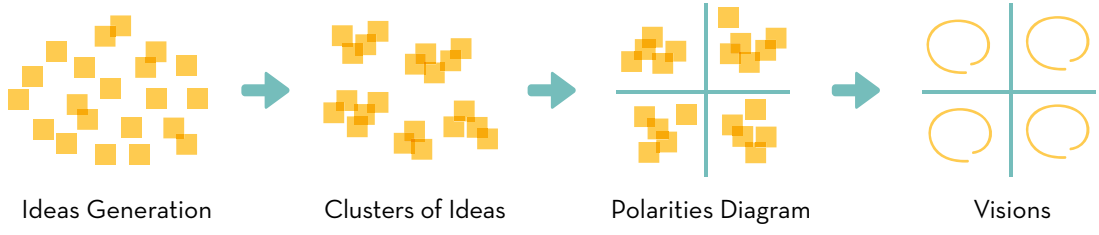
2.1. INTRODUCTION

The first design result of the MSDS method is reached after the strategic analysis and the exploring opportunities phases is called the Sustainability Design-Orienting Scenario (SDOS). The aim of this process is to map out the ideas generated previously, using a purpose designed polarities diagram. This diagram, together with the mapped ideas, constitutes what it is known as a sustainability design-orienting scenario, i.e. a set of visions of how a context could evolve if certain dynamics (economic, regulatory and socio-cultural) took place and if certain design options were adopted. Therefore the scenario outlines a set of visions, or better, possible promising design orientations.

2.1. WHAT IS A SDOS?

A SDOS is a picture of some possible and promising configurations of a particular demand-offer system, in which socio-cultural, organisational and technological factors are combined to fulfil a particular demand of satisfaction, with a low environmental impact, a high socio-ethical quality and high economical and competitive value. In other terms the design process leading to the SDOS aims at exploring at exploring sustainable PSS opportunities, at proposing an organic set of possible company strategy re-orientations, all potentially sustainable (economically, environmentally and socio-ethically winning).

Figure 3.7
the componet of A SDOS



Sustainable visions and ideas and their clusters are intended as "tools" to suggest, orient and support the following development and implementation of a sustainable Product- Service System. Every vision in turn is described by a set of single ideas and clusters (sets of ideas with basic elements in common). These visions, single ideas and clusters, constitute the basis for discussion by which to identify the most promising directions in which to orientate system innovation

The visions are represented by the combination of 2 polarity axes identified as meaningful for the design context: one of them is usually related to the offer system (horizontal axis) and the other related to the level of customer level of participation (vertical axis). Each vision is a schematic narration of promising evolutions of a specific context in relation to sustainability aspects.

2.3. DRAWING UP SUSTAINABILITY DESIGN-ORIENTING SCENARIOS

The aim of this process is to map out the ideas generated previously, using a purpose designed polarities diagram. This diagram, together with the mapped ideas, constitutes what it is known as a sustainability design-orienting scenario, i.e. a set of visions of how a context could evolve if certain dynamics (economic, regulatory, and socio-cultural) took place and if certain design options were adopted. Therefore the scenario outlines a set of visions, or better, possible promising design orientations.

Every vision in turn is described by a set of single ideas and clusters (sets of ideas with basic elements in common). These visions, single ideas and clusters, constitute the basis for discussion by which to identify the most promising directions in which to orientate system innovation.

4.

THE SDOS FOR S.PSS TO DRE

1

INTRODUCTION

Consider as a whole, the Design-Orienting Scenario (SDOS) for distributed renewable energy Sustainability Design-Orienting Scenario (SDOS) for Sustainable Product Service System (S.PSS) applied to Distributed Renewable Energy (DRE) in low and middle-income (all) contexts are presented. They are picture of some possible and promising configurations of the DRE system base on S.PSS ideas, with a low environmental impact and high economical value. Sustainable PSS opportunities are highlighted, by proposing an organic set of possible company strategy re-orientations, all potentially sustainable (economically and environmentally winning).

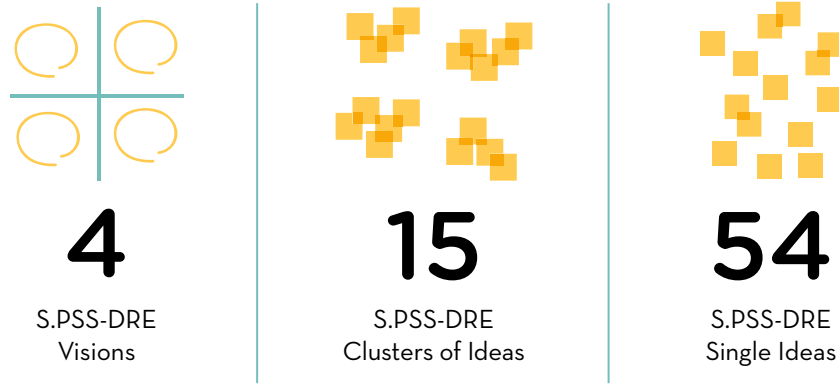


Figure 4.1
the SDOS scenario is described S.PSS-DRE visions, clusters of ideas and single ideas.

2

SUSTAINABLE DESIGN-ORIENTING SCENARIO POLARITY

2.1. HORIZONTAL AXIS

The first horizontal axis is related to the category of customer (users) of the distributed renewable energy for a small and middle-scale business/entrepreneur in low and middle-income (all) contexts.

B2B (Business To Business)

Focusing on the business that is conducted between companies (Energy suppliers/producers and single entrepreneurs/small medium entrepreneur) for upgrading energy system and start-up business in low and middle-income contexts.

Providers; according to the Distributed Renewable Energy system, the energy producers could be a multinational energy provider, the local/national public energy supplier, a small or medium size private energy company, a local cooperative of entrepreneurs, etc. providing the ownerless of Distributed Renewable Energy micro generator OR could be a partnership with energy using equipment and machineries create a full package from both Distributed Renewable Energy systems and the energy using equipment and machineries.

Receivers; Small and medium size entrepreneurs in low-middle income contexts (e.g. village scale, poor rural area, etc.) can connect Distributed Renewable Energy micro generator to the machineries and equipment (e.g. tailor shop, hair salon, laundry shop, small farmer, etc.) to run their business OR the single local entrepreneur can derive full package of Distributed Renewable Energy system and energy using products (e.g. Internet point, wood/metal workshop) to start up business.

B2C (Business to Consumer)

Focusing on the final user that is conducted directly between a company and single users or small communities in low and middle-income context who are the end-users of its products or services.

Providers; In the same way, energy suppliers of the Distributed Renewable Energy system could be a multinational energy provider, the local/national public energy supplier, a small or medium size private energy company, a local cooperative of entrepreneurs, etc. providing the ownerless of Distributed Renewable Energy micro generator OR could be a partnership with energy using equipment and machineries create a full package from both Distributed Renewable Energy systems and the energy using products and equipment.

Receivers; Single users and small communities in low-middle income contexts (e.g. village scale, poor rural area, etc.) will receive Distributed Renewable Energy micro generator that connect to the individual energy using product OR package for daily life needs (e.g. lighting systems, cooking and washing appliances, mobile phone, radio, TV, etc.)

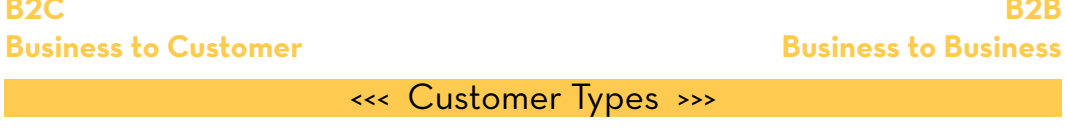


Figure 4.2
The first horizontal axis is related to the customer type (users); B2B (Business to Business) and B2C (Business to Customer)

2.2. VERTICAL AXIS

The second vertical axis is related the configuration of distributed renewable energy (micro generator and energy using product) that promising in all contexts as enabling service platform or full package.

Distributed renewable energy micro generator is production of energy for electricity on a small-scale form low carbon sources (e.g. solar, wind, hydro, biomass) The various micro generator technologies have some potential to help energy industry worldwide achieve targets for tackling climate change, ensuring reliable energy and tackling fuel poverty (e.g. solar photovoltaic systems use the power of the sun to generate green electricity and therefore reduce the amount of conventional electricity you draw from the National Grid).

Distributed renewable energy micro generator

This energy supplier (could be multi national energy provider, big-medium-small private energy company and the local/national public energy supplier and local cooperative) creates a DRE micro-generator and accessories (batteries, inverter, etc.) and retain the ownership of the DRE system, so forth cutting initial investemnt costs without a connection to the main energy grid (stand alone ditributed energy system) that can connect with energy using product in daily life for final users and machineries for small business in order to access the electricity and reduce the cost of energy, that lead to environmental impact reduction and improving social-ethical in low and middle-income contexts. The payment could either be fixed and based on period (daily/weekly/monthly payments) or based on energy use time of daily life products

Distributed renewable energy micro generator and Energy using product

A partnership between the energy supplier and the energy using products producers could be established and both the Distributed Renewable Energy systems and the energy using products remain in the partnership ownership create a DRE micro-generator and accessories (batteries, inverter, etc.) with energy using product (e.g. lighting, cooker, washing machine) or machineries (e.g. woodworking, farming machines) as a full package or platform that can improve their quality of life, health and security and offer the opportunities of business for people in in low and middle-income contexts

The "customer types" and "offers boundaries" are crossing the options just described gives rise to four visions, represented by the four quadrants in the polarity diagram. Finally, each vision, being a promising evolution of a specific context in relation to sustainability product service-system aspects, is described by a short text.

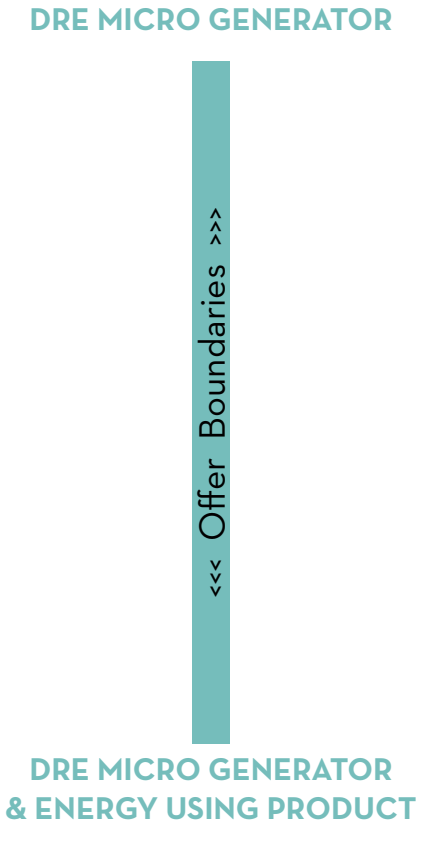


Figure 4.3
The second vertical axis is related the offer boundaries of distributed renewable energy (DRE) and energy using product (EUP)

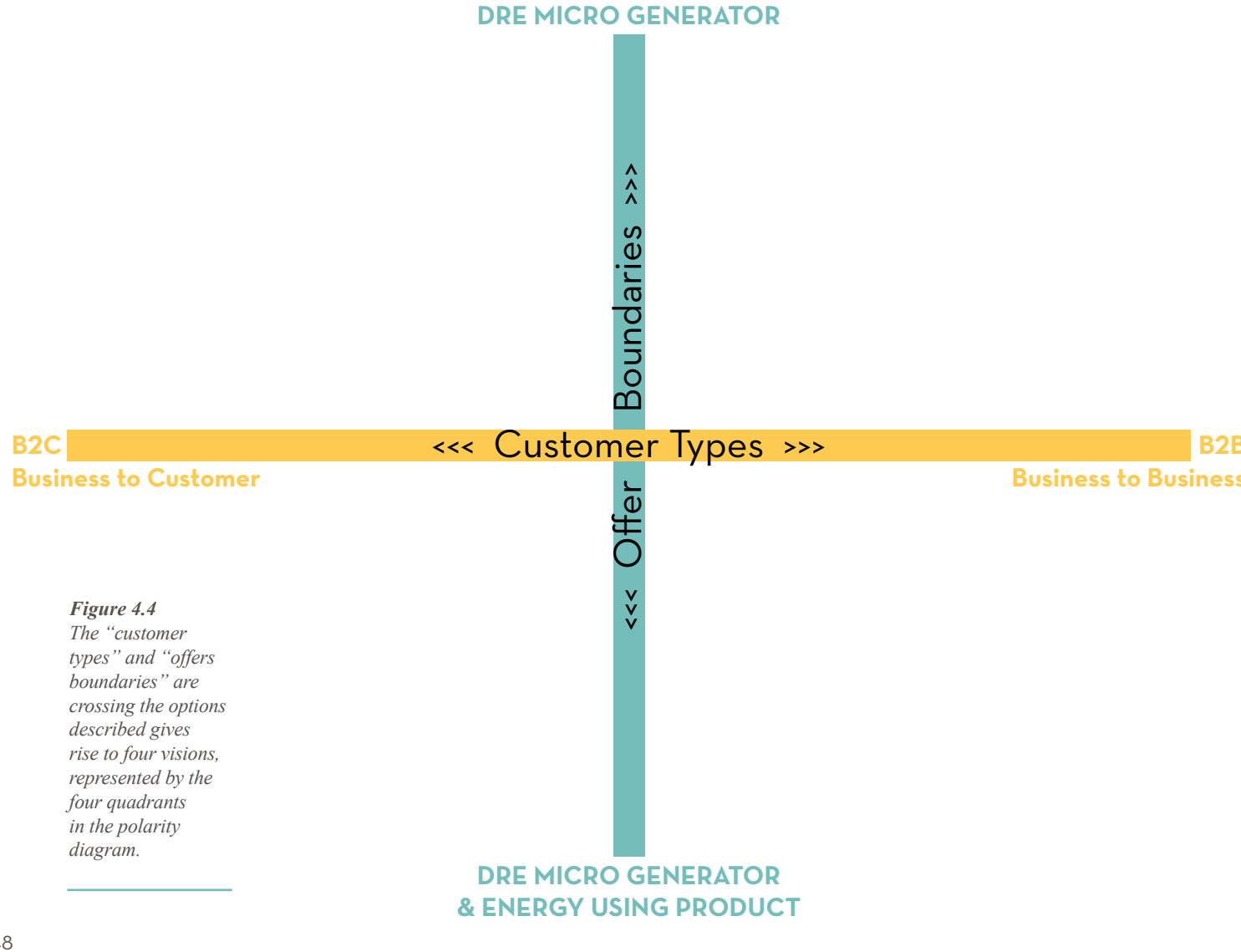


Figure 4.4
The "customer types" and "offers boundaries" are crossing the options described gives rise to four visions, represented by the four quadrants in the polarity diagram.

3

SUSTAINABLE DESIGN-ORIENTING SCENARIO VISIONS

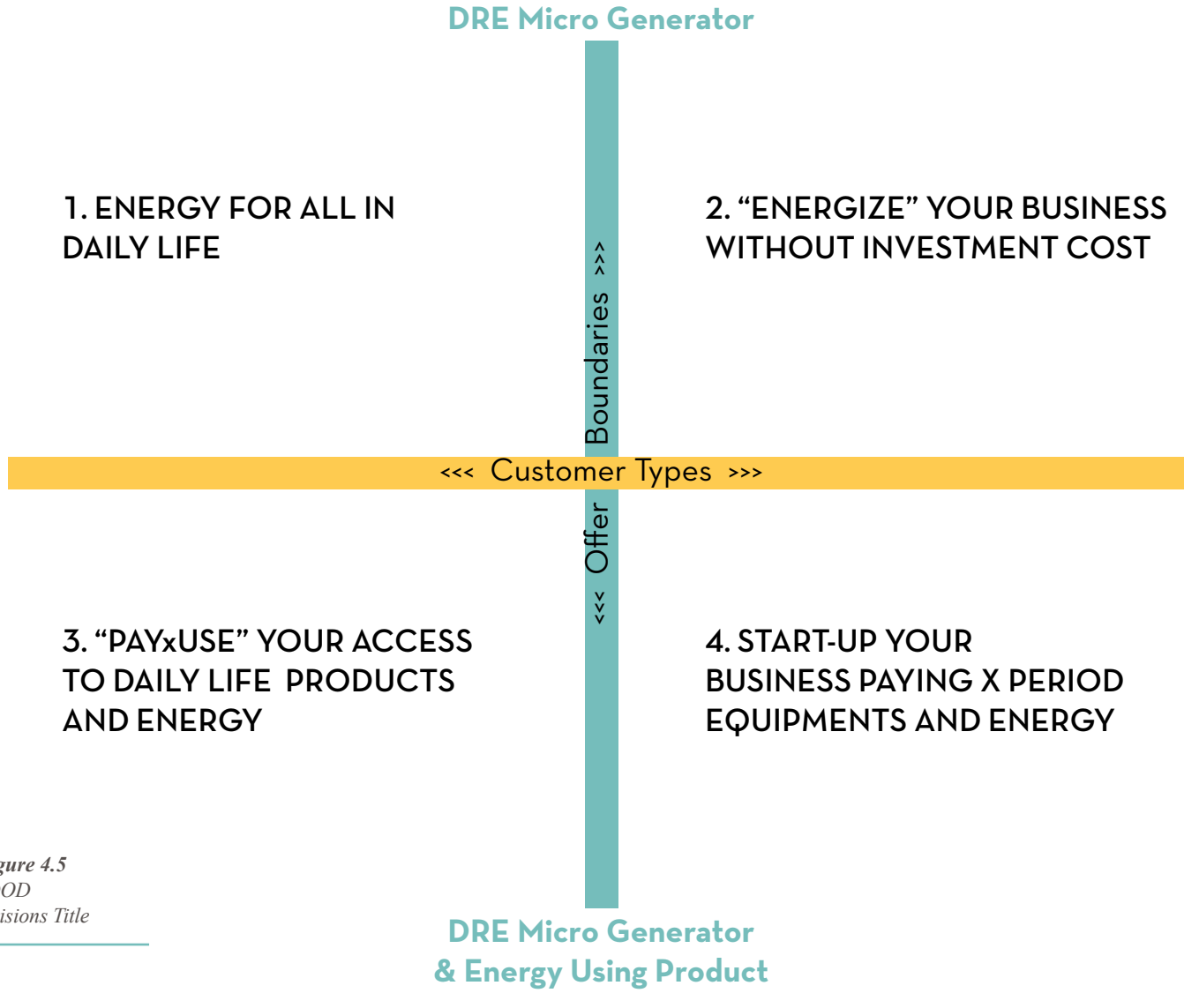


Figure 4.5
SDOD
4 visions Title

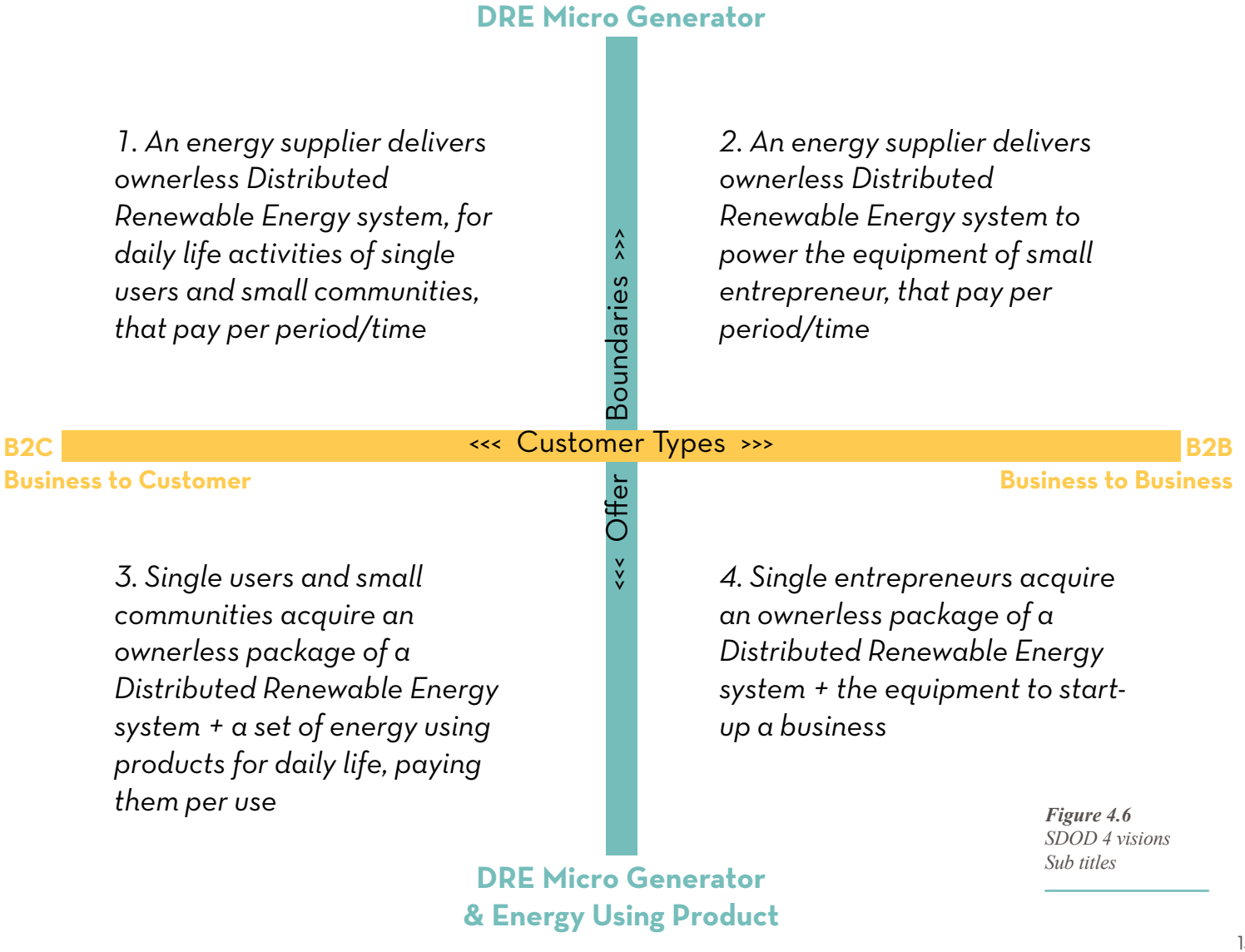


Figure 4.6
SDOD 4 visions
Sub titles

VISION 1

ENERGY FOR ALL IN DAILY LIFE

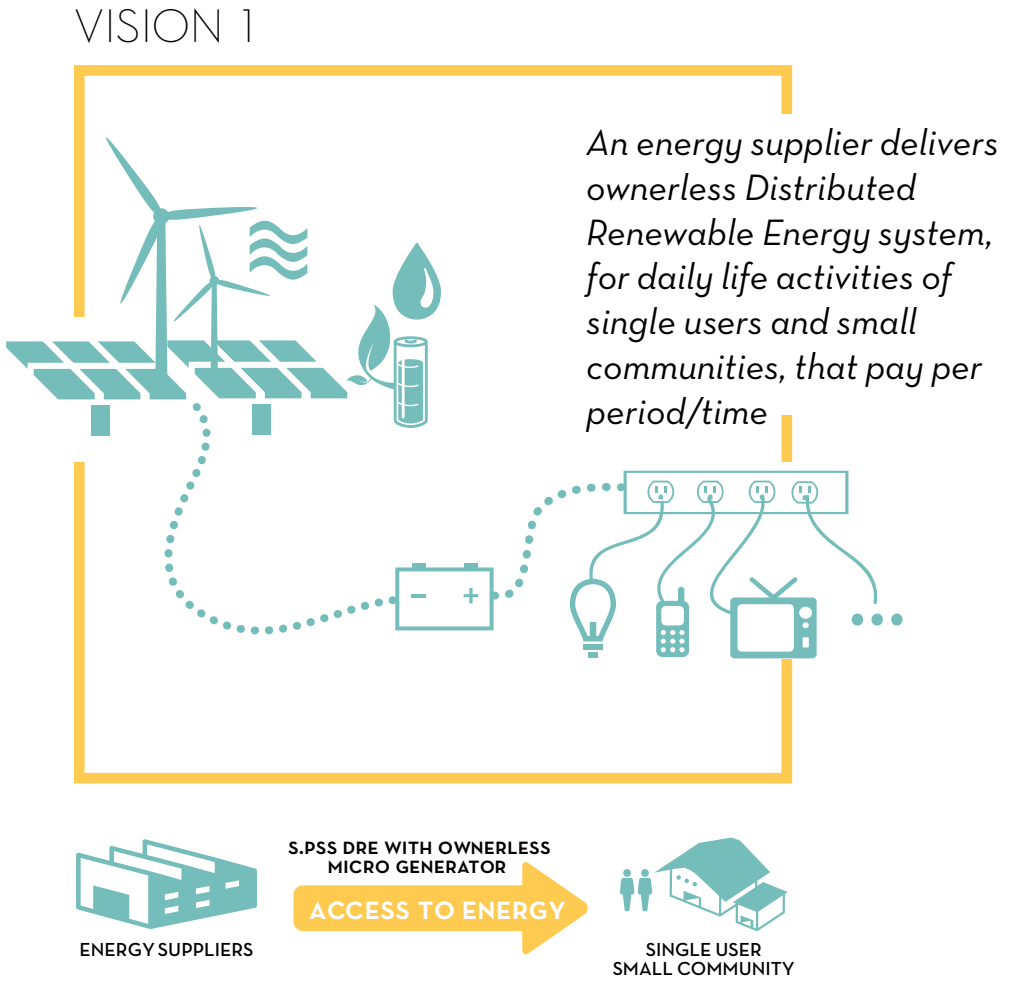


Figure 4.7
Infographic Vision 1

VISION 1

ENERGY FOR ALL IN DAILY LIFE

An energy supplier delivers Distributed Renewable Energy (DRE) system to power daily life activities products of single users and small communities. The energy supplier retain the ownership of the DRE system, so forth cutting initial investemnt costs for houses and communities without a connection to the main energy grid. Since DRE systems don't have most of resources extraction and refinement costs of fossil fuel-based ones, the payment is delinked form mere watt consumption; so forth the payment could either be fixed and based on period (daily/weekly/monthly payments) or based on energy use time of daily life products or finally based on hybrid modalities. Such an offer makes energy access economically affordable even for single users and small communities in low-middle income contexts, e.g. slum and poor rural area, that may greatly improve their quality of life, health and security.

The users connect daily life energy using product (for lighting, coking and washing appliances, mobile phone, radio, TV, etc.) to the DRE system provided by the energy supplier either at home or in a nearby community-based charging point (e.g. kiosk). The payiment can either be managed via a subscription prepay card at the local shop or adding the credit by mobile phone to get the code to access the energy, etc.

An energy supplier delivers ownerless Distributed Renewable Energy system, for daily life activities of single users and small communities, that pay per period/time

The offer could be an all-inclusive package with services such us installation, maintenance, repairing and substitution, upgrade and end of-life treatments of the various DRE components, e.g. micro generator, battery, inverter, etc. (result oriented-S.PSS). The offer could alternatively provide, together with the DRE system, the information and/or training on design, installation, maintenance, repairing and/or end of-life treatments of the various DRE components (use oriented-S.PSS).

The energy supplier could either be a multinational energy provider, the local/national public energy supplier, a small or medium size private energy company, a local cooperative of the same users, etc. This energy supplier provide the DRE micro-generator retaining its ownership. All needed accessories for the DRE micro-generator (batteries, inverter, etc.) are provided either by the energy supplier or by other producers, eventually in partnership among them, anyhow without an ownership passage to the users. The offer could be extended to the delivery of a local minigrid connecting various nearby homes for energy surplus sharing, or the offer could include connection to main grid with meters measuring and accounting the energy transit in and out from the single users.

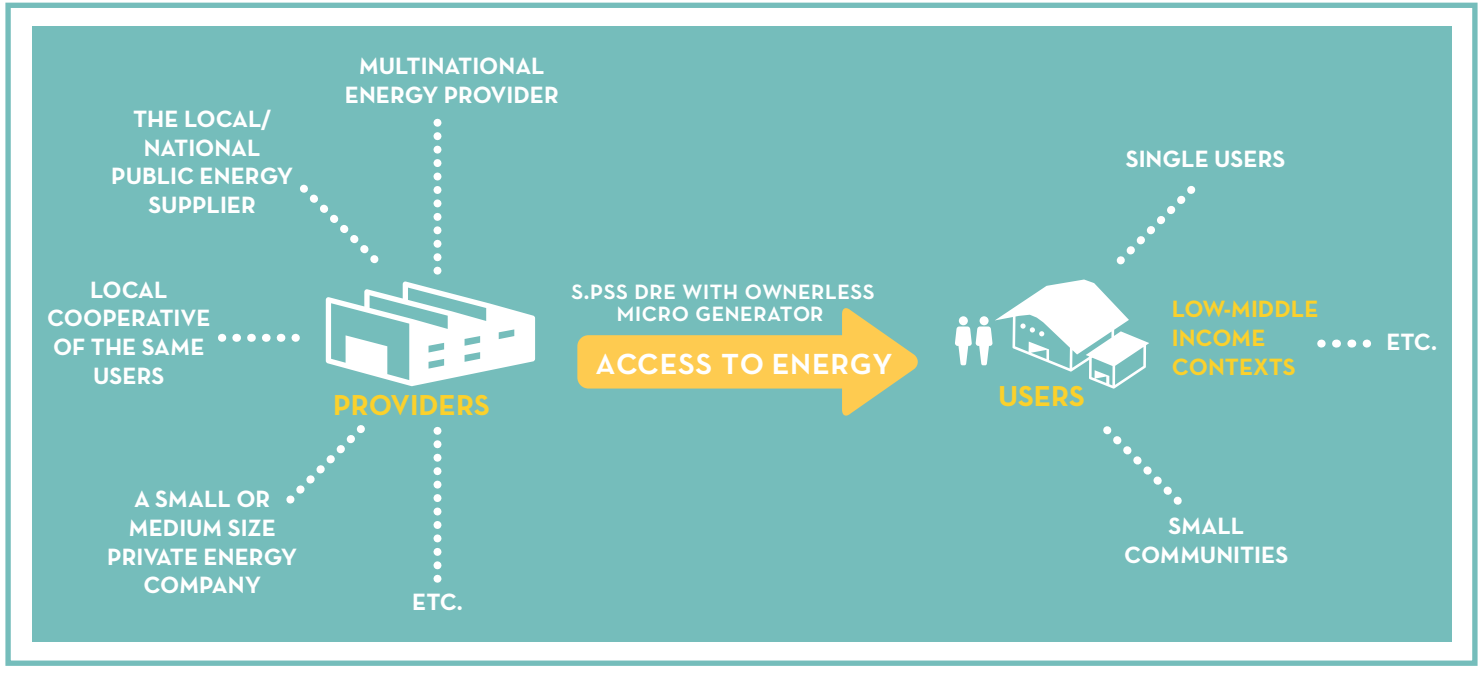


Figure 4.8
Map of providers and users, Vision1

VISION 1

ENERGY FOR ALL IN DAILY LIFE

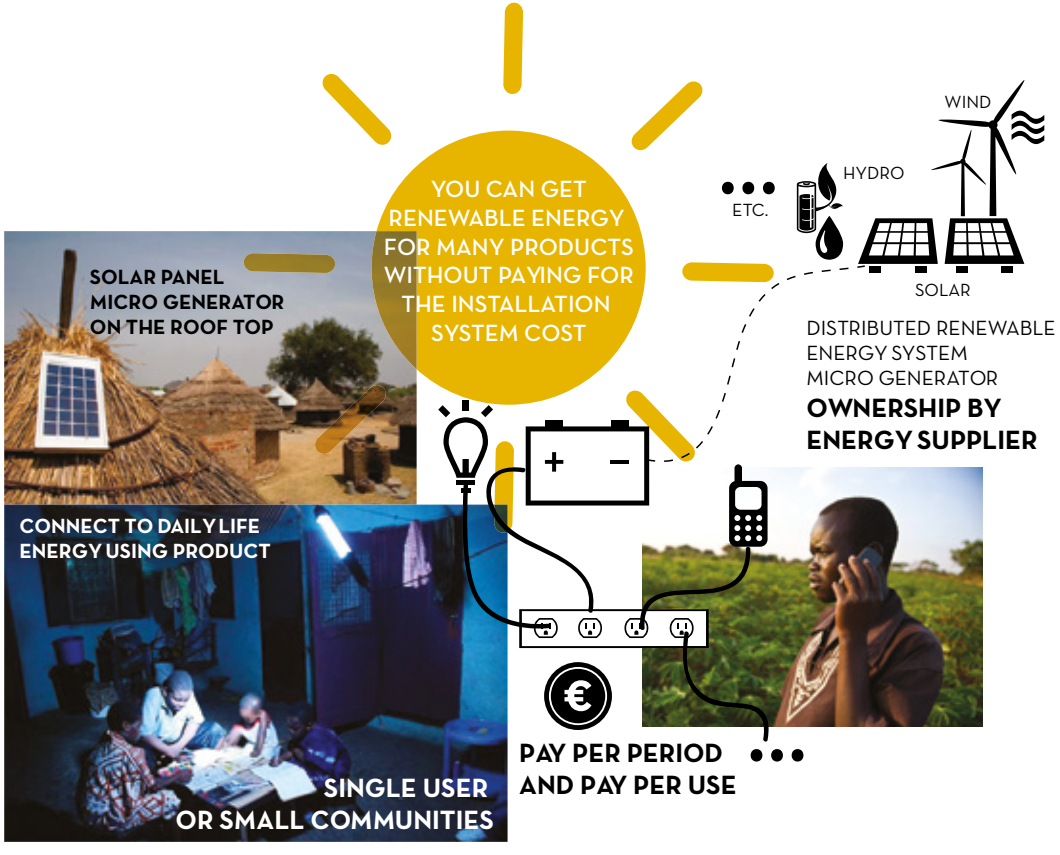


Figure 4.9
Poster Vision 1

VISION 2

“ENERGIZE” YOUR BUSINESS WITHOUT INVESTMENT COST

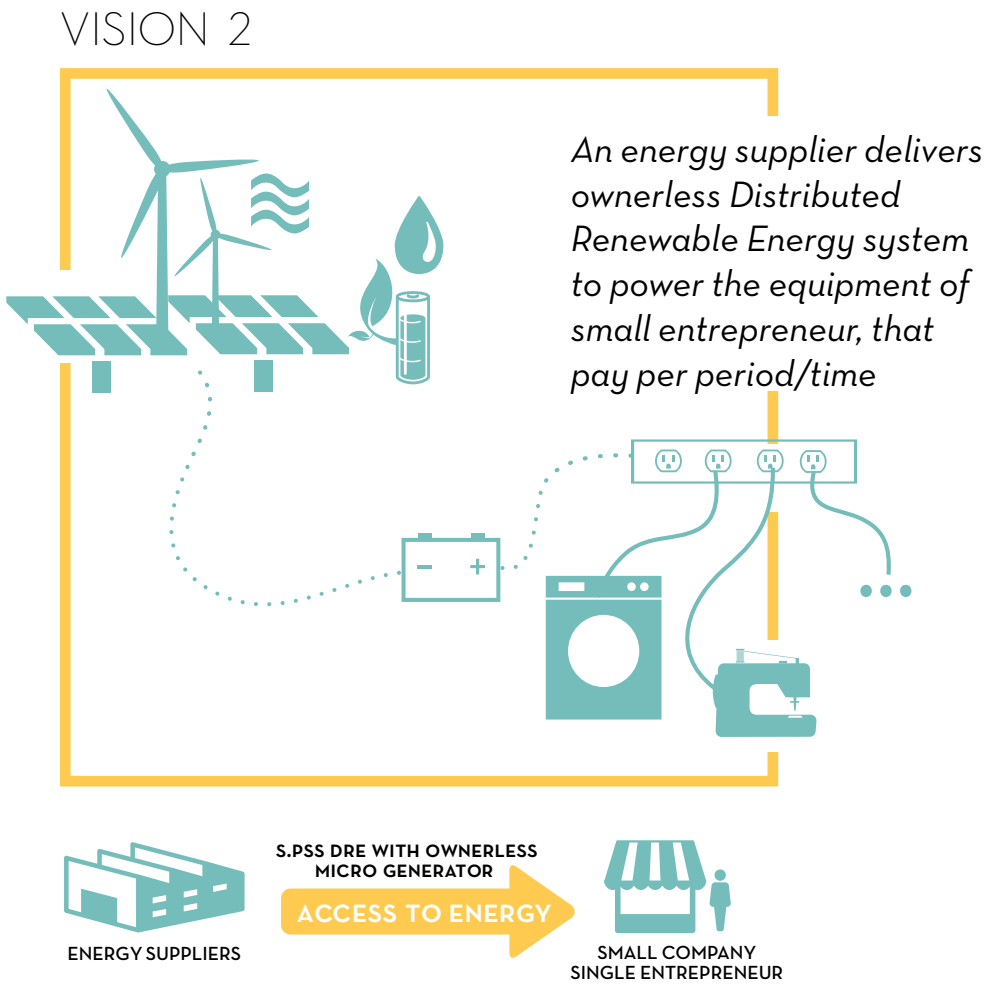


Figure 4.10
Infographic Vision 2

VISION 2

"ENERGIZE" YOUR BUSINESS WITHOUT INVESTMENT COST

An energy supplier delivers Distributed Renewable Energy (DRE) system to power machineries and equipment of small and medium size entrepreneurs/companies. The energy supplier retain the ownership of the DRE system cutting initial investemnt costs, for those business site without an energy grid connection. Since DRE systems don't have most of resources extraction and refinement costs of fossil fuel-based ones, the payment is delinked form mere watt consumption; so forth the payment could either be fixed and based on period (monthly/yearly payments) or based on machineries and equipment energy use time or finally based on hybrid modalities. Such an offer makes energy access economically affordable even for small entrepreneur in low-middle income contexts, e.g. slum and poor rural area, that may in this way increase their business opportunities and working conditions, finally empowering local economics growth.

The small and medium size entrepreneurs (e.g. tailor shop, hair salon, carpenter workshop, small farmer, etc.) can connect machineries and equipment (e.g. sewing machine, woodworking machine or metalworking machine, etc.) to the DRE system provided by the energy supplier at the company site. The payment based on fixed fee per given period of time (monthly/yearly payments) with long term contract.

An energy supplier delivers ownerless Distributed Renewable Energy system to power the equipment of small entrepreneur, that pay per period/time

The offer could be an all-inclusive package with services such as installation (connecting machineries and equipment to DRE system), maintenance, repairing and substitution, upgrade and end of-life treatments of the various DRE components, e.g. micro generator, battery, inverter, etc. (result oriented-S.PSS). The offer could alternatively provide, together with the DRE system, the information and/or training on design, installation, maintenance, repairing and/or end of-life treatments of the various DRE components (use oriented-S. PSS). Adding life cycle services …

The energy supplier could either be a multinational energy provider, the local/national public energy supplier, a small or medium sized private energy company, a local cooperative of entrepreneurs, etc. This energy supplier provide the DRE micro-generator retaining its ownership. All needed accessories for the DRE micro-generator (batteries, inverter, etc.) are provided either by the energy supplier or by other producers, eventually in partnership among them, anyhow without an ownership passage to the entrepreneurs. The offer could be extended to the delivery of a local minigrid connection or connection to main grid with meters measuring and accounting the energy transit in and out from the entrepreneurs.

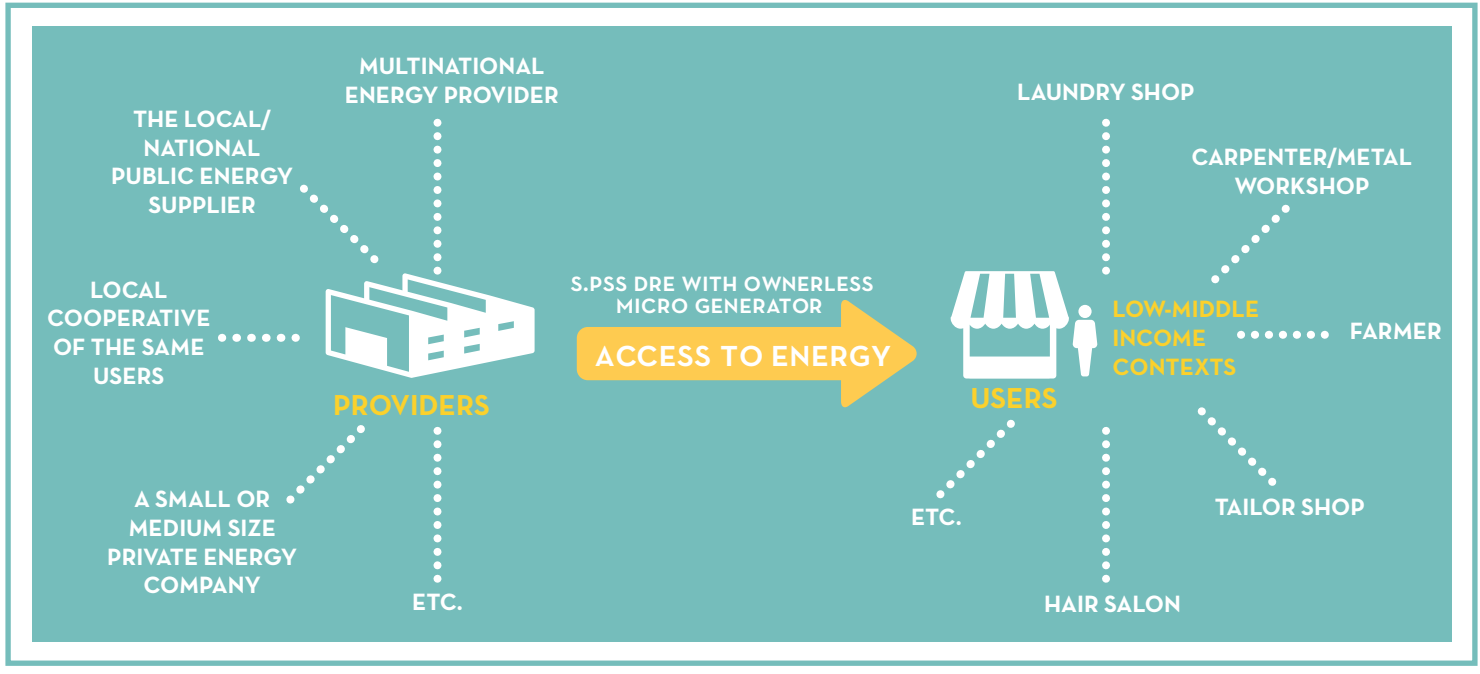


Figure 4.11
Map of providers and users, Vision2

VISION 2

"ENERGIZE" YOUR BUSINESS WITHOUT INVESTMENT COST

Figure 4.12
Poster Vision 2

VISION 3

“PAYxUSE” YOUR ACCESS TO DAILY LIFE PRODUCTS AND ENERGY

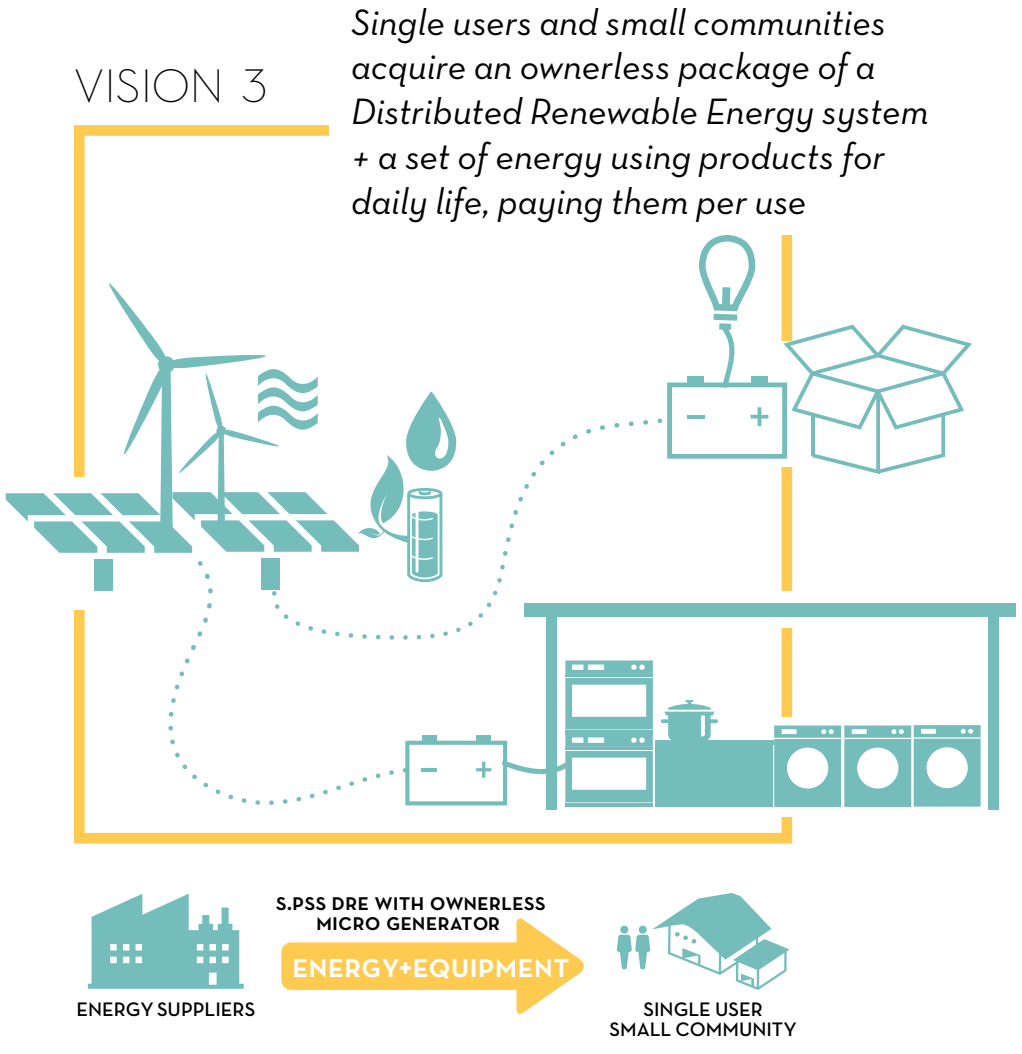


Figure 4.13
Infographic Vision 3

VISION 3

"PAYxUSE" YOUR ACCESS TO DAILY LIFE PRODUCTS AND ENERGY

Single users and small communities acquire an ownerless package of a Distributed Renewable Energy system and energy using products to meet their daily life needs and wants. The users don't get the ownership neither of the DRE system nor of the energy using products, so forth cutting initial investemnt costs of both connection to the main energy grid and purchase of energy using products. Since DRE systems don't have most of resources extraction and refinement costs of fossil fuel based ones, the payment is delinked form mere watt consumption; so forth the payment could either be per use (e.g. hours of light or number of washing cicles) or fixed and based on period (daily/weekly/monthly payments) or based on energy use time of daily life products or finally based on hybrid modalities. Such an offer makes access to energy and energy using products economically affordable even for single users and small communities in low-middle income contexts (e.g. several peoples are still using candle for lighting and firewood for cooking) that may greatly improve their quality of life, health and security.

The users receive full package or platform in the communities of daily life energy using product (e.g. home lighting systems, cooking and washing appliances in common space) is provided by the energy supplier either at home or in a nearby community-based area. The DRE system provided either at home or in a nearby decentralized small plant connected to their houses. The payment can either be managed via a subscription prepay card at the local shop to get the code to access the energy or paying per unit satisfaction of time using and etc.

Single users and small communities acquire an ownerless package of a Distributed Renewable Energy system + a set of energy using products for daily life, paying them per use

The offer could be an all-inclusive package with services such us installation, maintenance, repairing and substitution, upgrade and end of-life treatments of both the energy using products and the various DRE components, e.g. micro generator, battery, inverter, etc. (result oriented-S.PSS). The offer could alternatively provide, together with the DRE system and the energy using products, the information and/or training on installation, maintenance, repairing and/or end of-life treatments (use oriented-S.PSS). Finally the offer could be a mix of the two, i.e. use and result-oriented S.PSS.

The provider could be the energy supplier (a multinational energy provider or the local/national public energy supplier) alone that offer both the Distributed Renewable Energy systems and a set of purchased energy using products, that all remain in its ownership. Alternatively a partnership between the energy supplier and the energy using products producers could be established and both the Distributed Renewable Energy systems and the energy using products remain in the partnership ownership. Finally a cooperative could be established within the community or group of people that will use the energy using products and the energy, that retains the ownership of the Distributed Renewable Energy systems and the energy using products.

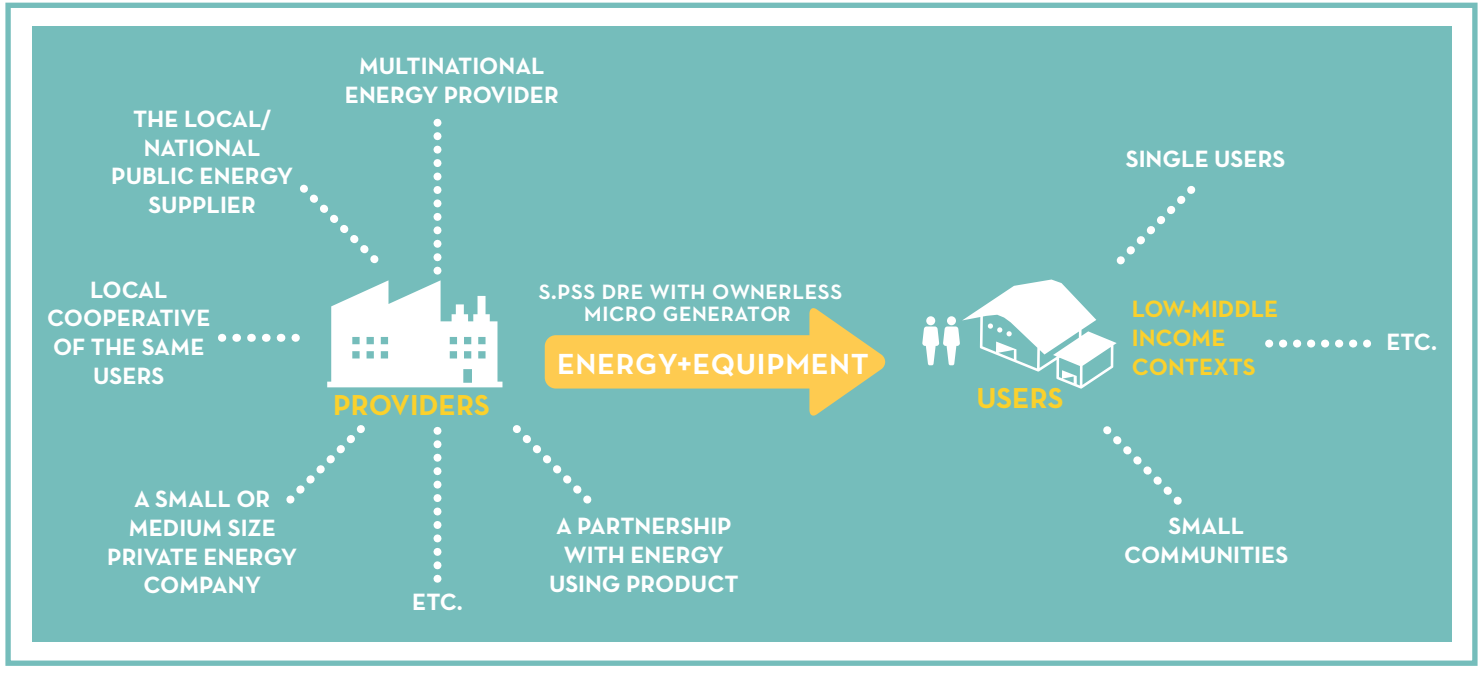


Figure 4.14
Map of providers and users, Vision3

Figure 4.15
Poster Vision 3

VISION 4

START-UP YOUR BUSINESS PAYING X PERIOD EQUIPMENTS AND ENERGY

VISION 4

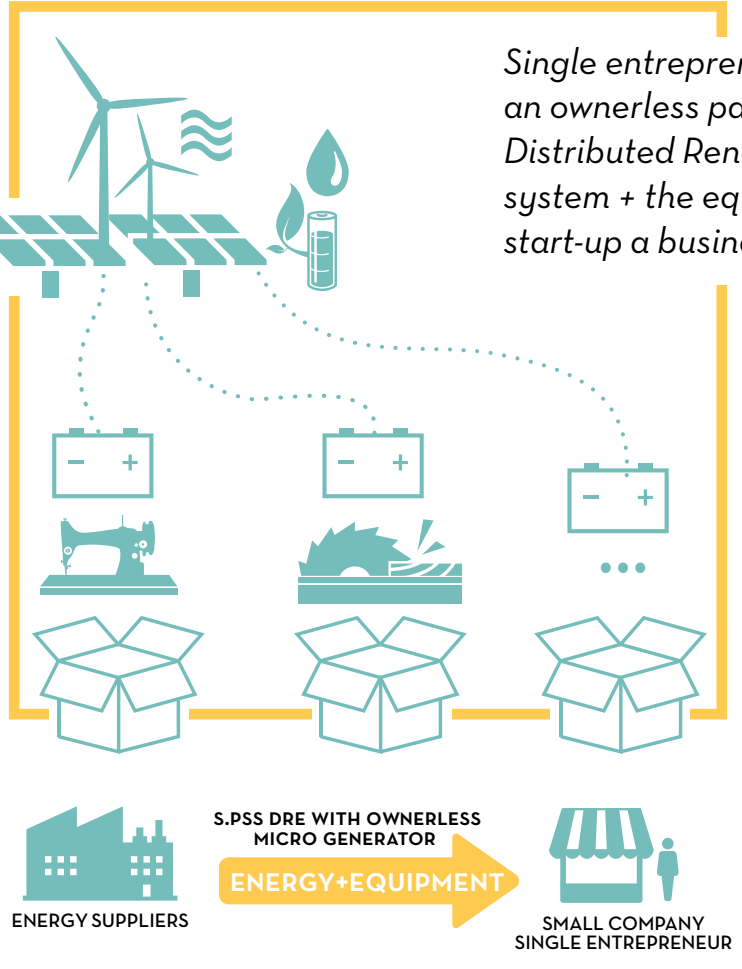


Figure 4.16
Infographic Vision 4

VISION 4

START-UP YOUR BUSINESS PAYING X PERIOD EQUIPMENTS AND ENERGY

Single entrepreneurs acquire an ownerless package composed by a Distributed Renewable Energy system and energy using equipment and machineries to start-up or upgrade her/his business. The entrepreneurs don't get the ownership neither of the DRE system nor of the energy using equipment and machineries, so forth cutting initial investment costs of both the connection to the main energy grid (when this is not available) and the purchase of the equipment and the machineries. Since DRE systems don't have most of resources extraction and refinement costs of fossil fuel-based ones, the payment is delinked form mere watt consumption; so forth the payment could either be fixed and based on period (monthly/yearly payments) or based on energy use time of energy using equipment and machineries or finally based on hybrid modalities. Such an offer makes access to energy and energy using equipment and machineries economically affordable even for single entrepreneurs in low-middle income contexts (e.g. several competent entrepreneurs in low income contexts don't get any loan from mostly diffused traditional banks) that may in this way increase their business opportunitie, working conditions and startup their business empowering the local community and local economic growth.

The single entrepreneurs connect the acquired energy using equipment and machineries (e.g. sewing machine, wood or metal workshop equipment, internet point computers, etc.) to the DRE system provided either at the company site or in a nearby decentralized and connected small plant. The payment based on fixed fee per given period of time (monthly/yearly payments) with long term contract.

Single entrepreneurs acquire an ownerless package of a Distributed Renewable Energy system + the equipment to start-up a business

The offer could be an all-inclusive package with services such us installation, maintenance, repairing and substitution, upgrade and end of-life treatments of both the energy using equipment and machineries and the various DRE components, e.g. micro generator, battery, inverter, etc. (result oriented-S.PSS). The offer could alternatively provide, together with the DRE system and the energy using equipment and machineries, the information and/or training on installation, maintenance, repairing and/or end of-life treatments (use oriented-S. PSS). Finally the offer could be a mix of the two, i.e. use and result-oriented S.PSS.

A partnership between the energy supplier (a multinational energy provider or the local/ national public energy supplier) and the energy using equipment and machineries could be established and both the Distributed Renewable Energy systems and the energy using equipment and machineries remain in the partnership ownership. The offer could be extended to the delivery of a local mini grid connection or connection to main grid with meters measuring and accounting the energy transit in and out from the entrepreneurs.

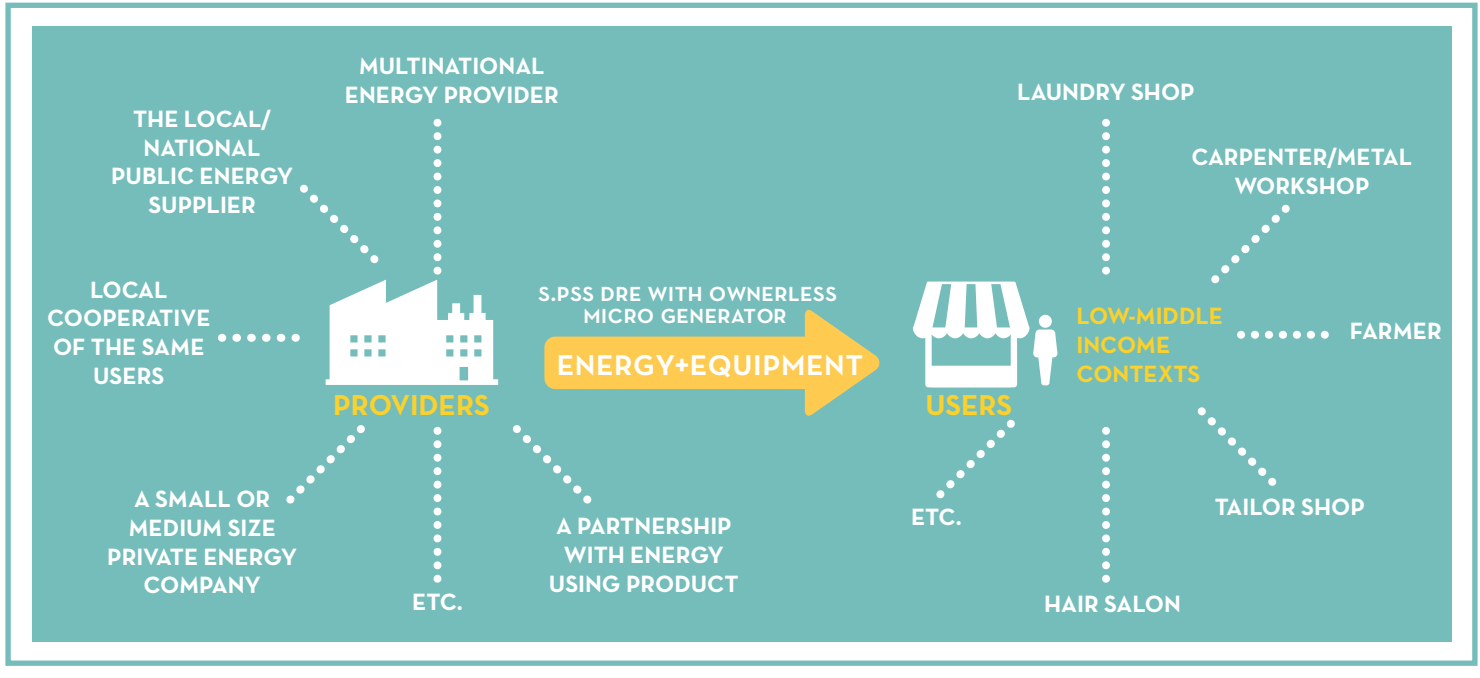


Figure 4.17
Map of providers and users, Vision4

VISION 4

START-UP YOUR BUSINESS PAYING X PERIOD EQUIPMENTS AND ENERGY

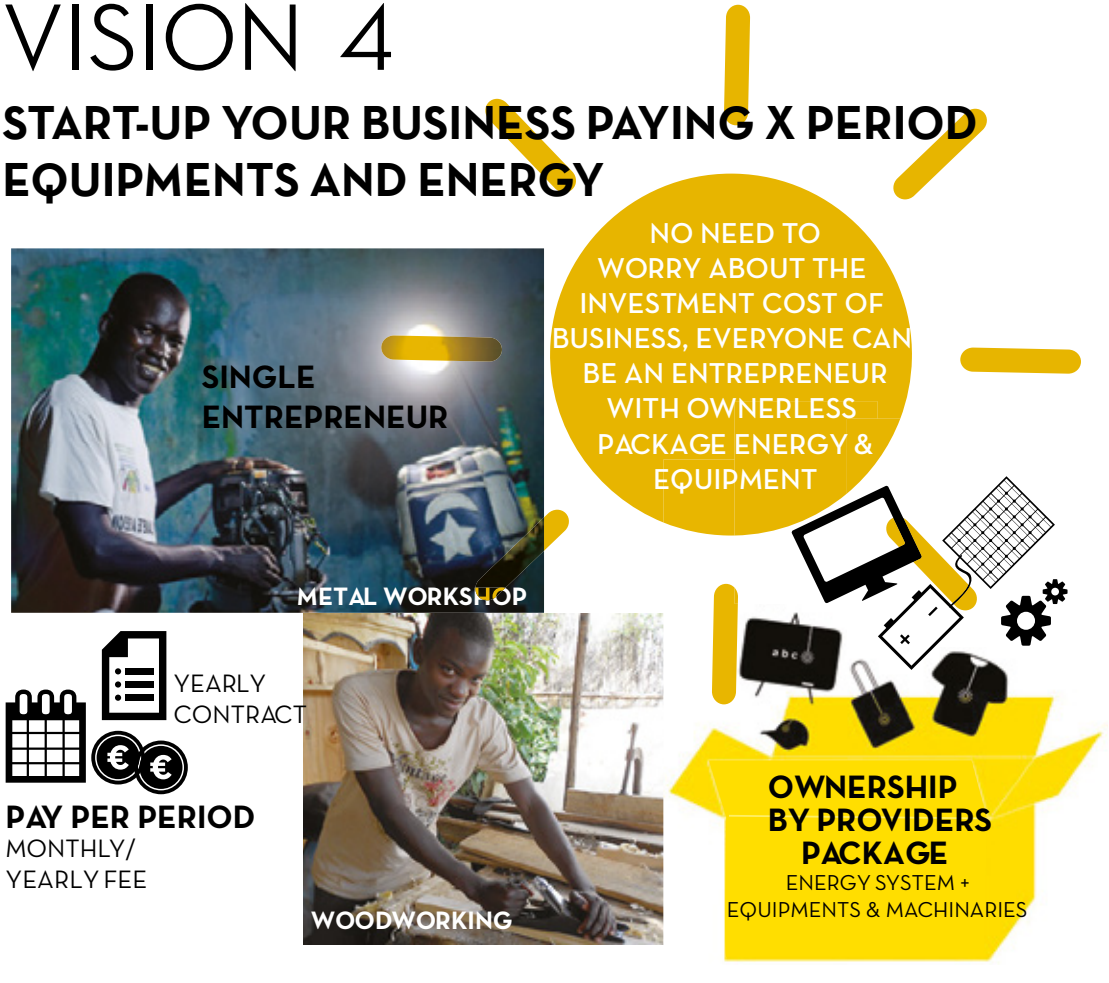


Figure 4.18
Poster Vision 4

4

SUSTAINABLE DESIGN-ORIENTING SCENARIO

CLUSTER OF IDEAS AND SINGLE IDEAS

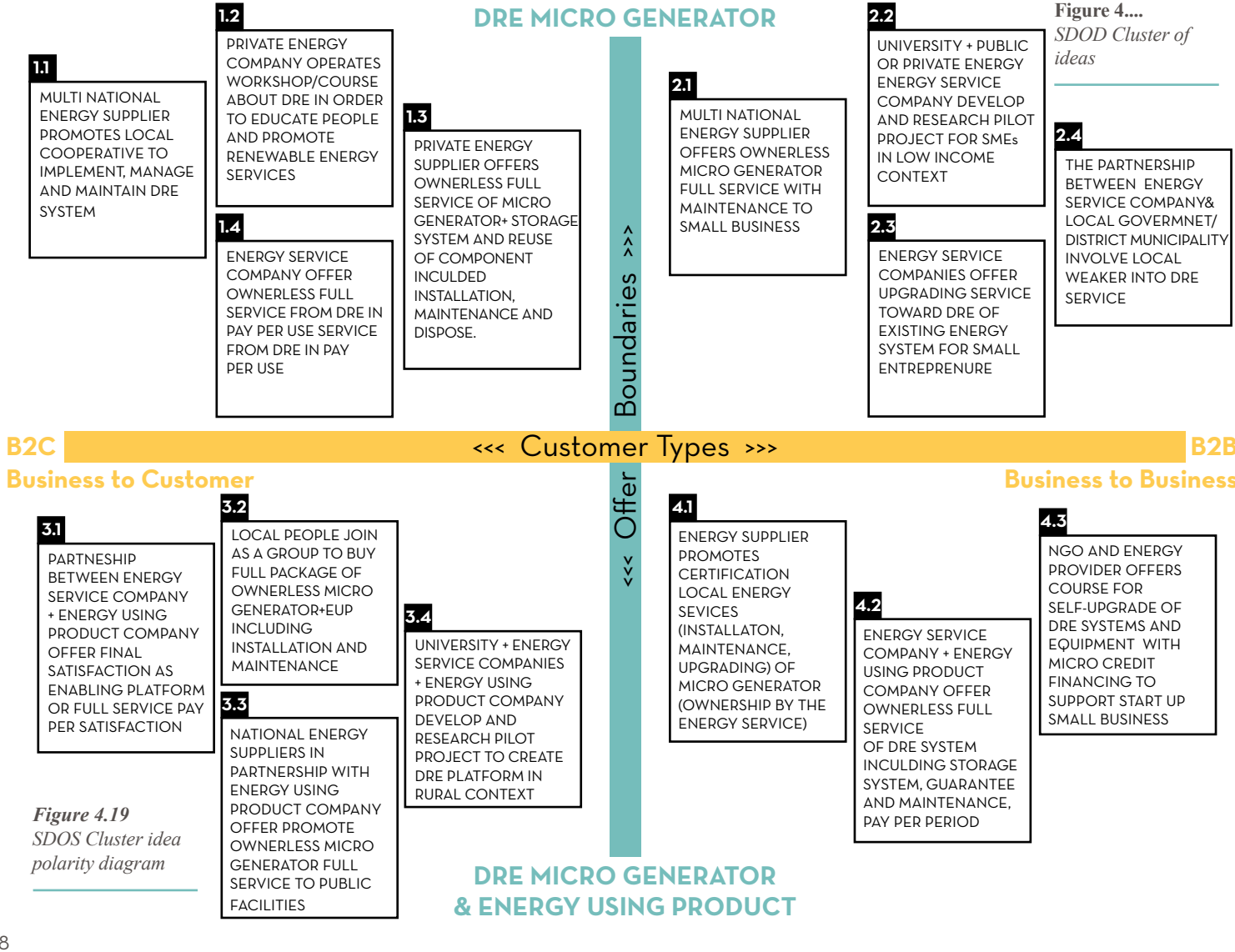


Figure 4....
SDOD Cluster of ideas

Figure 4.19
SDOS Cluster idea polarity diagram

This clustering help achieve an understanding of main innovations possibility explored under each of the visions. The eco-efficient clusters PSS ideas are listed under the vision they belong to, and for each of the cluterare listed the eco-efficient single PSS ideas. Each idea is identified by a color to highlight the environmental criteria they respond to The environmental and Social-ethical criteria. according to the codes.

The 6 Environment criteria

- **A** System life optimisation
- **B** Transportation/distribution reduction
- **C** Resource reduction
- **D** Waste minimisation/valorisation
- **E** Conservation/biocompatibility
- **F** Toxicity reduction

The 6 Social-ethical criteria

- **A** Improve employment/working conditions
- **B** Improve equity and justice in relation with stakeholders
- **C** Enable responsible/sustainable consumption
- **D** Favour/integrate the weak and marginalised
- **E** Improve social cohesion
- **F** Empower/valorise local resources

VISION 1

ENERGY FOR ALL IN DAILY LIFE

1.1. MULTI NATIONAL ENERGY SUPPLIER PROMOTES LOCAL COOPERATIVE TO IMPLEMENT, MANAGE AND MAINTAIN DRE SYSTEM

- **A** Local organization in rural contexts operate sharing and exchanging labors (technician and operator) to maintain distributed renewable energy system for everyday use
- **F** Local cooperative of distributed renewable energy organizes meeting/event to promote and discuss the problems and get feedback in order to be guild line or the future improvement

1.2. PRIVATE ENERGY COMPANY OPERATES WORKSHOP/COURSE ABOUT DRE IN ORDER TO EDUCATE PEOPLE AND PROMOTE RENEWABLE ENERGY SERVICES

- **C** Media company and energy service companies support the use of advance technology to enable saving energy behavior and promote the innovative distributed renewable energy though entertainment
- **A** Local Department of energy create “Distributed Renewable Energy Center” providing useful information about basic maintenance. Local users can share and exchange distributed renewable energy knowledge

An energy supplier delivers ownerless Distributed Renewable Energy system, for daily life activities of single users and small communities, that pay per period/time

1.3. PRIVATE ENERGY SUPPLIER OFFERS OWNERLESS FULL SERVICE OF MICRO GENERATOR+ STORAGE SYSTEM AND REUSE OF COMPONENT INCULDED INSTALLATION, MAINTENANCE AND DISPOSE.

- **C** Solar power supplier operate ownerless full service with installation and maintenance for user, just pay for actual time of use
- **D** Energy service company of micro generator and storage system will take back service aimed at re-using, re-manufacturing and recycling
- **D** **C** Local Government manages “solar home system repair” to the existing home solar system. The payment of service including installation, guarantee, maintenance and upgrading, pay yearly fee

1.4. ENERGY SERVICE COMPANY OFFER OWNERLESS FULL SERVICE FROM DRE IN PAY PER USE SERVICE FROM DRE IN PAY PER USE

- **B** **F** Partnership between energy service company and local operator provide energy platform in common area in the small village for cooking in pay per time using the energy
- **F** **C** Energy suppliers cooperate with the national Telecompany to provide kiosk for recharge mobile phone with prepay card

VISION 2

"ENERGIZE" YOUR BUSINESS WITHOUT INVESTMENT COST

2.1. MULTI NATIONAL ENERGY SUPPLIER OFFERS OWNERLESS MICRO GENERATOR FULL SERVICE WITH MAINTENANCE TO SMALL BUSINESS

- **A** Energy service companyprovides financial support to start-up energy service entrepreneur for local people to improve energy access in rural area, entrepreneur would able to repay energy service company after 2-3 years
- **F** Small business get distributed renewable energy connection to energy using product such as sewing machine, washing machine to run the business

2.2. UNIVERSITY + PUBLIC OR PRIVATE ENERGY ENERGY SERVICE COMPANY DEVELOP AND RESEARCH PILOT PROJECT FOR SMEs IN LOW INCOME CONTEXT

- **C** **E** Private energy service company introduce workshop to the university to generate new idea of sustainable energy service and energy access for small business in urban and rural context

An energy supplier delivers ownerless Distributed Renewable Energy system to power the equipment of small entrepreneur, that pay per period/time

2.3. ENERGY SERVICE COMPANIES OFFER UPGRADING SERVICE TOWARD DISTRIBUTED RENEWABLE ENERGY OF EXISTING ENERGY SYSTEM FOR SMALL ENTREPRENURE

- **D** Energy service company offer upgrading distributed renewable energy service for business in rural and urban context. Users pay for the first repair and upgrading system, and make repayments over a two-year period
- **A** Upgrading distributed renewable energy service will provide digital platform to users to recalculate the annual energy consumed and financial calculator such as cost of system, and electricity rate.

2.4. THE PARTNERSHIP BETWEEN ENERGY SERVICE COMPANY& LOCAL GOVERMNET/ DISTRICT MUNICIPALITY INVOLVE LOCAL WEAKER INTO DISTRIBUTED RENEWABLE ENERGY SERVICE

- **A** Creating job for poor people for instance installation and maintenance energy service that improve energy access in rural area
- **D** Involving disable people for repetition work (ex. production of micro generator of component solar PV)
- **B** Retired people can do the volunteer work for a charity or distributed renewable energy community organization
- **D** Involving prisoners for production, installation and maintenance of micro generator and energy system

VISION 3

"PAYxUSE" YOUR ACCESS TO DAILY LIFE PRODUCTS AND ENERGY

3.1. PARTNESHIP BETWEEN ENERGY SERVICE COMPANY + ENERGY USING PRODUCT COMPANY OFFER FINAL SATISFACTION AS ENABLING PLATFORM OR FULL SERVICE PAY PER SATISFACTION

- **C** Local users get product for free + guarantee but pay for electricity (recharge), in pay per period
- **C** Energy Using Product company and Energy Service Company offer ownerless of DRE service (ex. washing machine) sharing for local people, pay per use
- **B** Create big and share ownerless energy (co housing, common kitchen) to improve relationship between young and old people, pay per satisfaction

3.2. LOCAL PEOPLE JOIN AS A GROUP TO BUY FULL PACKAGE OF OWNERLESS MICRO GENERATOR + ENERGY USING PRODUCT INCLUDING INSTALLATION AND MAINTENANCE

- **E** A group of inhabitants in rural context join to purchase micro generator including installation and maintenance service (solar PV, hydro power, small wind power)
- **C** Cooperative collecting membership of regional scale to purchase micro generator of distributed renewable energy

Single users and small communities acquire an ownerless package of a Distributed Renewable Energy system + a set of energy using products for daily life, paying them per use

3.3. NATIONAL ENERGY SUPPLIERS IN PARTNERSHIP WITH ENERGY USING PRODUCT COMPANY OFFER PROMOTE OWNERLESS MICRO GENERATOR FULL SERVICE TO PUBLIC FACILITIES

- **A** Join venture between micro generator producer and temporary energy using product ex. washing machine and water supplier provide cleaning cloth service
- **F** - **F** Local organization and energy service company improve the eating system in low-middle income context by solar oven, the oven that use energy from solar. Final user only pay per use

3.4. UNIVERSITY + ENERGY SERVICE COMPANIES + ENERGY USING PRODUCT COMPANY DEVELOP AND RESEARCH PILOT PROJECT TO CREATE DRE PLATFORM IN RURAL CONTEXT

- **F** University + infrastructure organization + energy service companyresearch and develop the used of solar + storage system for start engine and renewable fuel for vehicle
- **C** Electrical appliances company and student from the university develop products using distributed renewable energy to create pilot project in rural and urban context
- **A** Water supplier and university develop desalination system plant by distributed renewable energy system for fresh water in rural context, reduce transportation clean water in rural context

VISION 4

START-UP YOUR BUSINESS
PAYING X PERIOD EQUIPMENTS AND ENERGY

4.1. ENERGY SUPPLIER PROMOTES CERTIFICATION LOCAL ENERGY SEVICES (INSTALLATON, MAINTENANCE, UPGRADING) OF MICRO GENERATOR (OWNERSHIP BY THE ENERGY SERVICE)

- A Energy Service Company operate ownerless energy rental service and product equipment as a full service to local small business
- D Energy supplier offer full packaging energy service including micro gen and storage system to recover and treatment of toxic/ harmful component resources (battery magnetic of micro generator)
- A Energy supplier has responsibility to train local technician for upgrading distributed renewable energy micro generator and maintenance energy service
- B A Create a partnership with local construction companies to integrate micro generator of DRE in urban and rural context

Single entrepreneurs acquire an ownerless package of a Distributed Renewable Energy system + the equipment to start-up a business

4.2. ENERGY SERVICE COMPANY + ENERGY USING PRODUCT COMPANY OFFER OWNERLESS FULL SERVICE OF DRE SYSTEM INCULDING STORAGE SYSTEM, GUARANTEE AND MAINTENANCE, PAY PER PERIOD

- **A** Local health institute and energy service provider of micro generator distributed renewable energy and storage system offer for health care service container by solar energy included medical service, vaccine as a full service, in pay monthly fee
- **E** Solar internet cafe', full service of internet cafe included equipment (computer, printer and etc.) and solar system to generate electricity, with yearly contact and monthly payment

4.3. NGO AND ENERGY PROVIDER OFFERS COURSE FOR SELF-UPGRADE OF DRE SYSTEMS AND EQUIPMENT WITH MICRO CREDIT FINANCING TO SUPPORT START UP SMALL BUSINESS

- **A** Local bank and Energy Service Company provided loan and credit with lower interest for start up business with distributed renewable energy micro generator ownership by provider
- **D** NGO and Energy Service Company operate self-upgrading course of distributed renewable energy and equipment for local entrepreneur and small business
- **A** Energy service provider creates application on mobile phone users both individual and small business in which financial calculator and recalculate energy output in real time

5

SUSTAINABLE DESIGN ORIENTING SCENARIO VIDEOS

5.1. VIDEO STRUCTURE

The aim of SDOS video is to promote and present the ideas of S.PSS how to apply with distributed renewable energy especially in low and middle-incomes context for PSS designer, the energy supplier, government, local institute, district municipality, organization and people in general. This video can be adapted as a tool to improve ideas and concept of distributed renewable energy projects in the future step.

The video structure chart describes how the video will be presents the ideas of S.PSS applied to DRE possibilities ideas through short story of four S.PSS visions and in each vision is divided into 4 videos; one main video and three sub videos.

5.1.1. Main Video

From S.PSS applied to DRE vision can be presented through the narrative short story of some example situation in low and middle-income contexts about the basic problems of access to energy in daily life both single users and small businesses. The main idea of story provides possibility of some solutions in terms of using the DRE energy to improve their quality of life, health and security and working condition that empowering local economic growth. The actors could be people in communities such as male, female, child, doctor, seller, neighbor, and so on who are living in small village poor rural area.

5.1.1. Sub Video

Sub video 1: Providers and Users

This video will be introduced who could be the actors and the stakeholders' interaction with the service. The provider could be the energy supplier (a multinational energy provider or the local/national public energy supplier) provides the DRE micro-generator retaining its ownership. It could be a partnership between the energy supplier and the energy using products producers could be established and both the Distributed Renewable Energy systems and the energy using products remain in the partnership ownership. On the other hand, users could be people in low-middle income contexts (e.g. slum and poor rural area) either single, small communities for activities in daily life and small entrepreneurs for business opportunities.

Sub video 2: Payment

This part will be explained "how to pay the service" such an offer makes energy access economically affordable even for single users and small entrepreneur in low-middle income contexts

Sub video 3: Why the service is sustainability

The last video will be concluded the entire story "why the service is sustainability" base on the Product-Service System design criteria of social-ethical, environmental and economic sustainability, with a low environmental impact, a high socio-ethical quality and high economic competitive value.

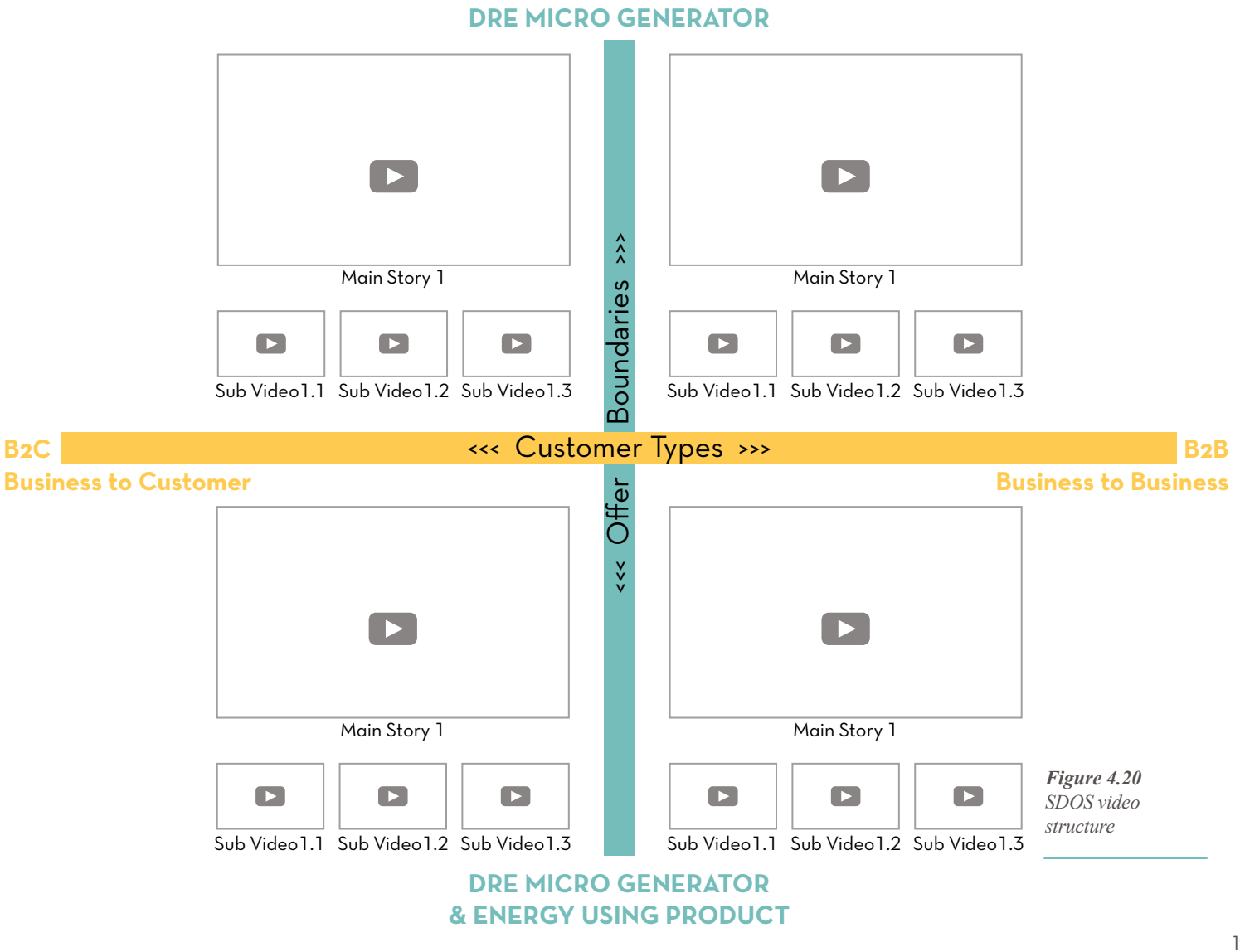


Figure 4.20 *SDOS video structure*

5.2. SUSTAINABLE DESIGN-ORIENTING SCENARIO VIDEO VISIONS

The final presentation will be presented 4 vision's videos (including main video and sub videos) through the short story. In this part will be started from brief story, personas (actors), storyboard and audio text, 3 sub videos and sustainable key characteristic in each story vision.

Vision 1 : Recharge with solar energy

Max live in the village without electricity, he lost communication with mom during her emergency accident because the battery finished. small scale off-grid energy could be the solution to recharge battery mobile phone at home.

Vision 2 : Solar Sewing Machine

Tom and Kate need more electricity power to connect with another sewing machine for their business. The problem is the main grid is unstable, but the micro generator of DRE could be the solution to provide more electricity.

Vision 3 : Solar Pay Per Cook

Ryan got sick from the toxic of burning wood. Mary take him to the hospital to meet doctor. He give the new idea of cooking by the solar energy in pay per cook as full service and enabling platform.

Vision 4 : Carpenter solar package

Ben is carpenter who has very good skill to make wood products. he has a dream to use woodworking machine to improve his skill and produce local wood furniture. this full service package of energy and machinery without investment cost can make his dream come true.

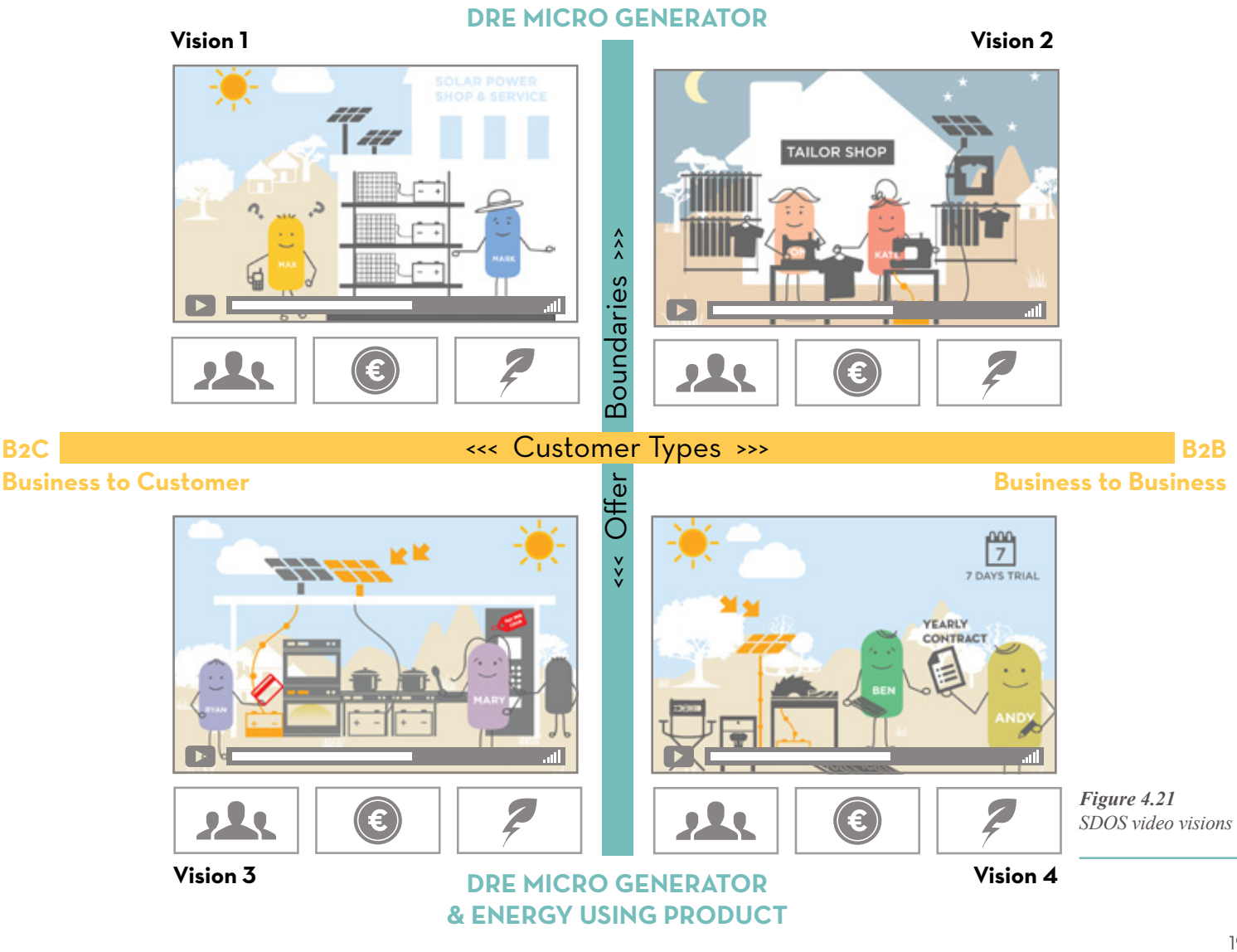


Figure 4.21
SDOS video visions

VISION 1: **ENERGY FOR ALL IN DAILY LIFE**

An energy supplier delivers ownerless Distributed Renewable Energy system, for daily life activities of single users and small communities, that pay per period/time

In the rural area without electrcity, Max received the call from his mom because of emergency illness at midnight. During Max talking with his mom, the battery of mobile phone is going to be empty. Then they lost the communication each other. At that night he can't sleep because he is so worry about his mom. In the morning he immediately go to meet his mom. Fortunately it is not a serious case, his mom getting better.

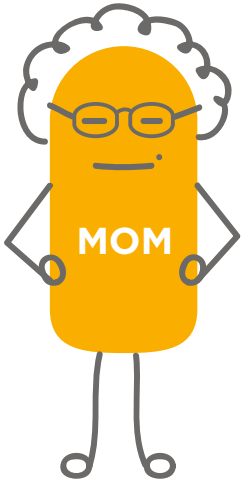
This situation would not happen again! He is thinking about how to get the new way to recharge battery for mobile phone. He goes to another city to find rechargeable battery. Max found one solar energy shop, but he was not interesting in solar system because it would be very expensive.

Marco presents the ownerless micro generator form solar panel package that can be used with many kind of product such as mobile phone, lighting, radio and etc. The company has a responsibility to maintenance, upgrade the service. Customer only pay for the energy per time or monthly/weekly fee Max is interested in this system because it simple, easy, costless and useful for many energy using product as well.

Max got solar panel on the rooftop that installed by Marco. DRE kit can provides the energy for daily life. He can be easily contact his mom anytime and get power for lighting Above all, this service change his life.

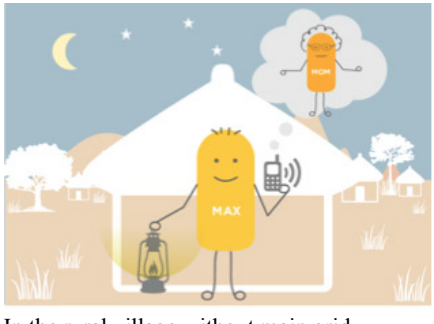
He is working as a manager in energy shop from energy supplier in south Africa.

He is 29 years old. he is farmer who working in the countryside without access electricity and far away from hometown in South Africa.

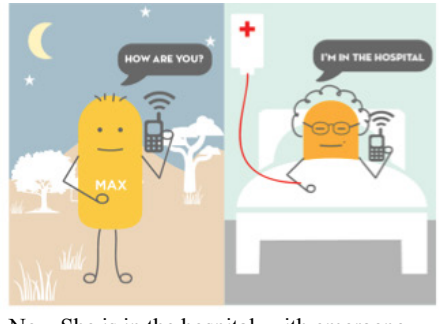


She is 59 years old. She has chronic disease about heart. Her hometown is in a small village, in rural area

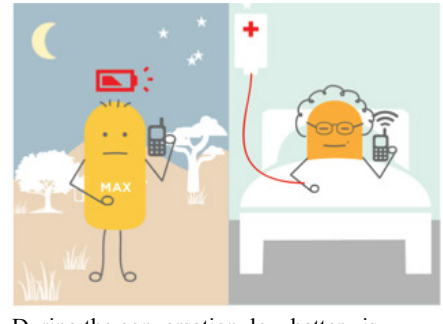
Figure 4.22
Personas Vision 1



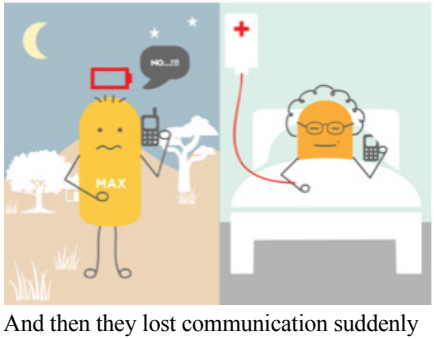
In the rural village without main grid connection, Max receive phone call from mom at midnight



Now She is in the hospital, with emergency accident



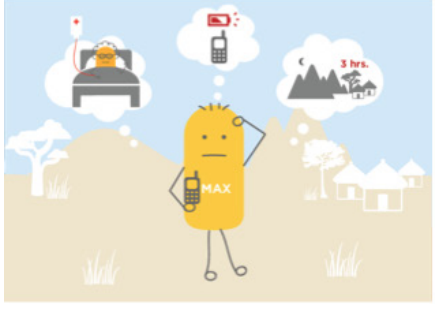
During the conversation, low battery is warning



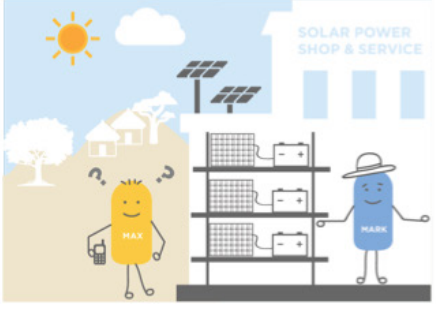
And then they lost communication suddenly

Max is so worry about it, He can't do anything

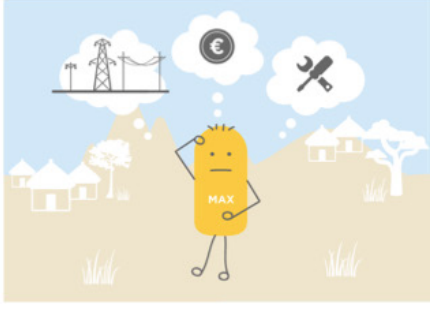
Early morning he take the bus go to meet his mom in the hospital



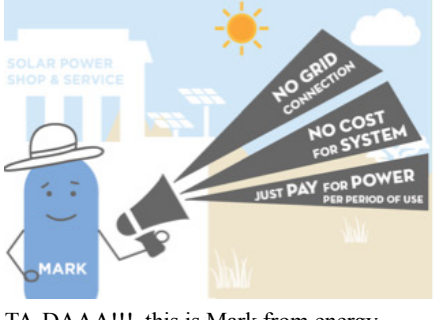
But he still worry the things that happen last night.



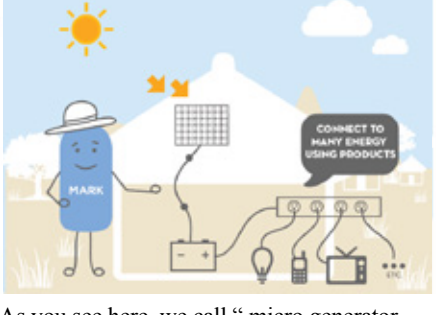
Finally, He found solar power shop and service



But his home cannot connect to the main grid, the cost of solar panel and maintenance is very high. He can't afford it!



TA-DAAA!!! this is Mark from energy supplier, he explain that this service has no grid connection, no cost of the system, just pay for power per period of use



As you see here, we call " micro generator For a Distributed renewable energy". He will receive electricity for product in daily life such as lighting, mobile phone, Television and so on

Max is so surprise that he can have it on the roof top

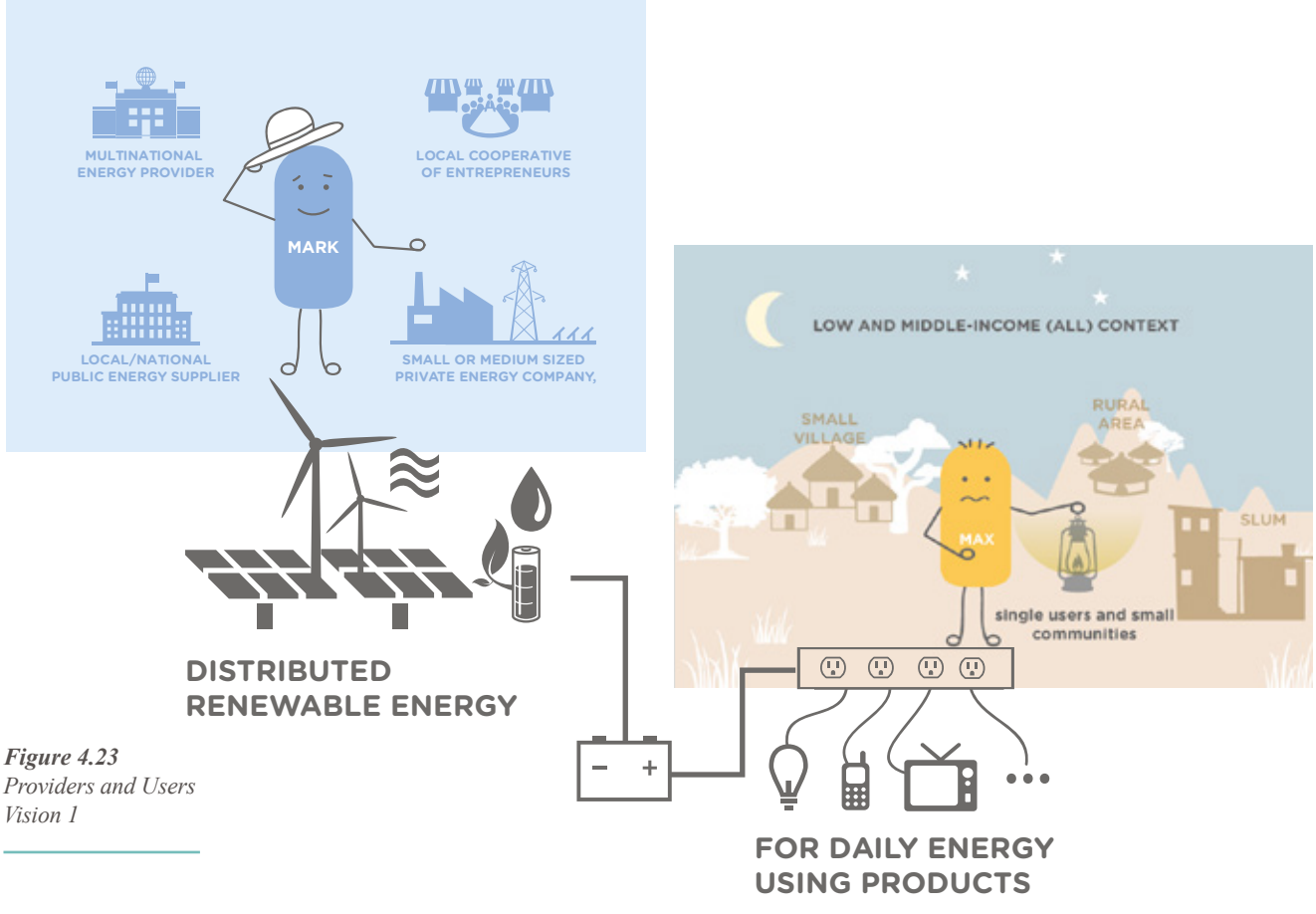
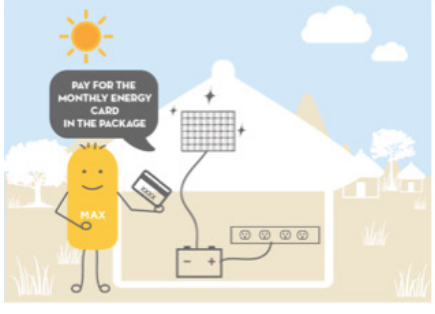
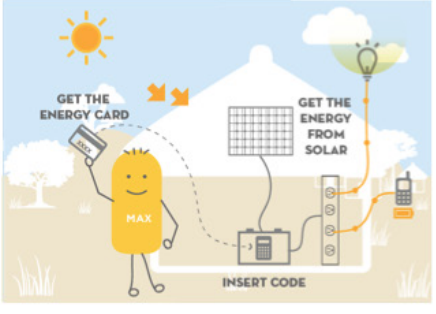


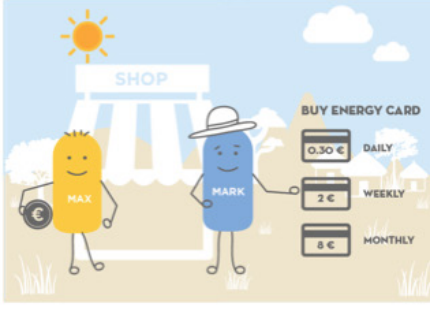
Figure 4.23
Providers and Users
Vision 1



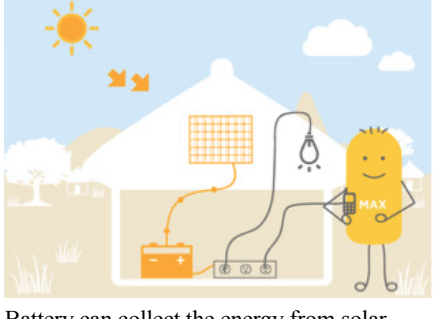
Max paid only for the monthly energy card in the package



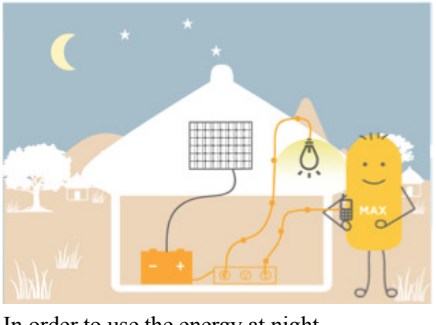
Just insert the code from the card, and you can get the energy from solar



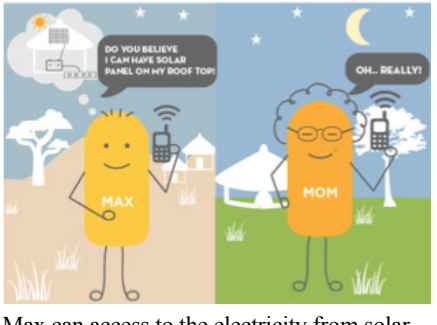
after finished the credit, he can buy energy card at the shop nearby for daily, weekly and monthly



Battery can collect the energy from solar panel during day time



In order to use the energy at night



Max can access to the electricity from solar panel on the roof top. that could be totally changed his life

VISION 1

Sub Video3 : Why the service is sustaianble?

Social-Ethical Sustainability

Improve social cohesion
People can read and and learn after sunset, enlarge education and improve mobile phone communication

Favor/integrate weaker and marginalized strata
By providing the distributed renewable energy systems and services in low and middle income contexts, it change their life in term of increasing their accessibility of electricity products in daily life activities.

Empower/valorize local resources
solar energy is available everywhere and it is free. It can be used to generate electricity by solar panel and battery (micro generator of DRE system)

Environmental Sustainability

System life optimization
the provider offer ownerless micro generator to final customer, taking care of installation and maintenance and repairing doing so the micro gen system system that could be last longer and be more efficient

Resource reduction, Toxic Reduction
Reduce the use of charcoal, kerosene (the cause of toxic from black carbon) to produce the energy and lighting

Conservation/biocompatibility
Using solar power to produce electricity produce electricity in daily life. And lees the use of power from the main grid

Transportation reduction
reduce the of local transportation to recharge mobile phone and get the energy from energy shop in city center.

Economical Sustainability

Add values for a customer
Energy service company offers without the initial cost. Thanks to the payment based on a periodical access by energy card such as daily-weekly-monthly. This service is a source of sustainable business and economic feasibility that will be the chance also for the people in low and middle income contexts could afford the price of access to the off grid electricity.

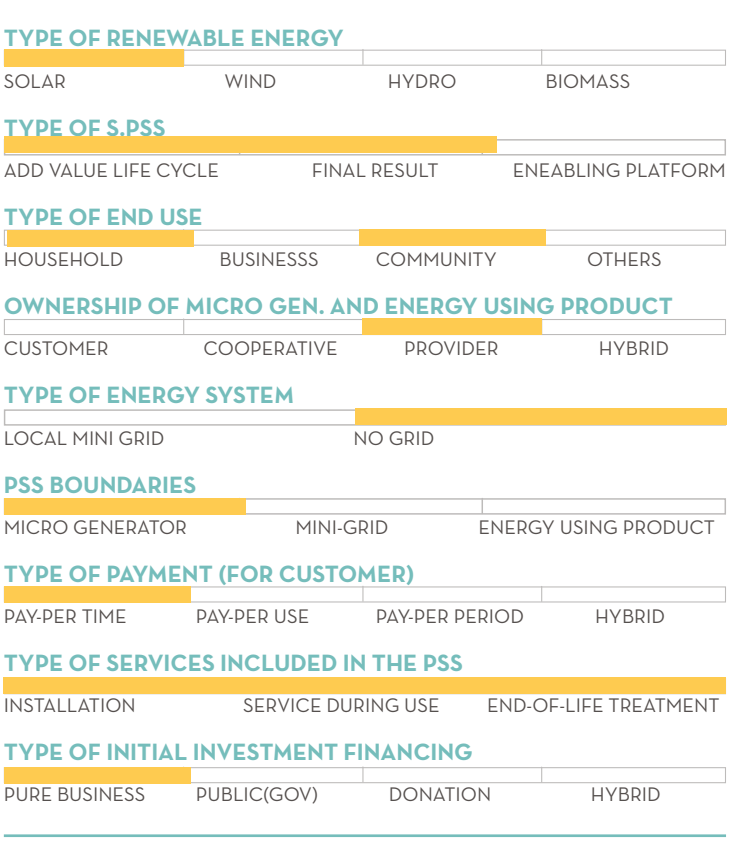


Figure 4.24
S.PSS Key characteristic Vision 1

VISION 2 : **"ENERGIZE" YOUR BUSINESS WITHOUT INVESTMENT COST**

An energy supplier delivers ownerless Distributed Renewable Energy system to power the equipment of small entrepreneur, that pay per period/time

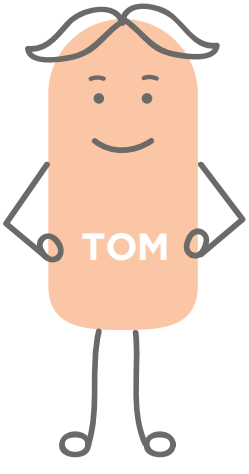
Tom and Kate are a couple and the owner of small tailor shop in the rural village. Before New year festival, a lot of people come to the tailor shop for fixing and buying a new clothes. Tom cannot finish all the work with only one sewing machine by himself. Kate bring another sewing machine but the problem is not enough electricity because the main grid is unstable.

in the morning, Kate goes to another village to buy fabric. Kate met Emma, her friend who is the owner of clothe shop in the village nearby. Kate discussed about the problem of sewing machine. Last year, Emma got the same problem as well, but now she has already got the solution. She invite Kate to her place.

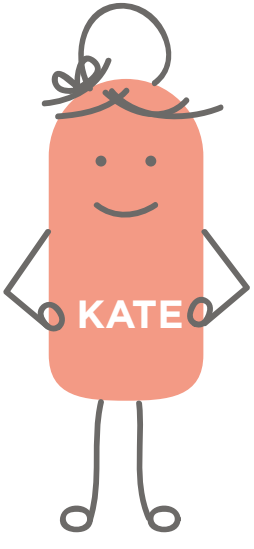
Kate knew that this village has the same problem about unstable main grid but how come Emma can have 2 sewing machine? Emma tell the solution that she connect one of her sewing machines with solar panel. Kate is so surprise! How she can do it?

Emma said that she just call the energy service company and made the requirement to get more energy. Solar energy is the best option because there is the package DRE micro generator to connect with all any kind of machines without investment cost. she got an appointment with technician, they will come to check the quality and electricity power. In the same time, the condition of service and payment are given by them. Customers need to sign yearly contact and pay fix rate every month that included installation, repairing and maintenance system.

Finally, Tom and Kate contact to the energy supplier company to get the energy service. The sewing machines from Emma is connected to the solar system. From now on they can work more productive without the problem of unstable main grid.



He is 32 years old. The owner of tailor business in small village



She is 29 years old. She is Tom's wife, she's working with Tom in tailor shop.

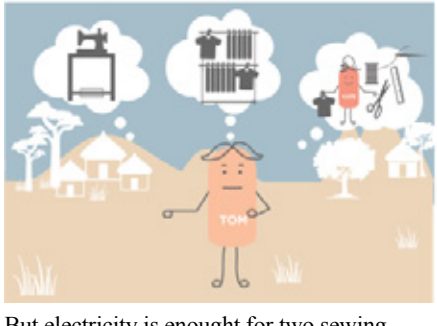
He is 35 years old. She is the owner clothes shop in another village

Figure 4.25
Personas Vision 2

Every year many people come to tailor shop before Christmas and new year festival

In the small village with the unstable main grid, for the tailor shop, the power enough for only one sewing machine

But they have a lot of work to do,
If they have another sewing machine, it could help them

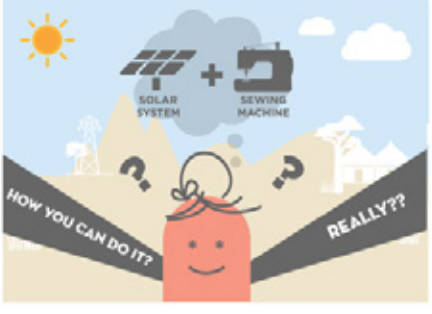


But electricity is enought for two sewing machine

Next day, Kate go to buy fabric in another village. she met Emma, her friend, and discuss about sewing machine problem

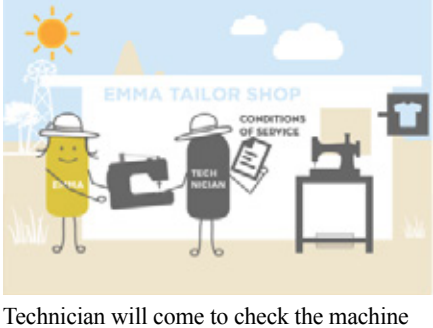
Emm invite Kate to her shop, Kate asks Emma why she can have 2 sewing machines? is the electricity enough?

Emma told that one of them connected with the solar system, no need to connect with the main grid



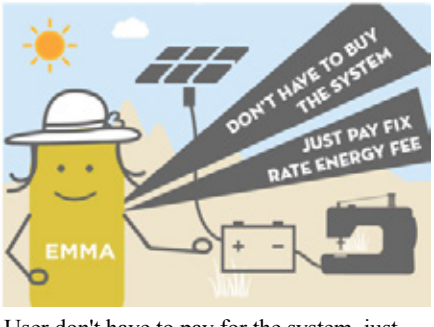
Kate is so surprise!

Just call the energy service company, ask them to connect the system with your machine



Technician will come to check the machine with the condition service document

Basically, this service is free for installation, maintenance and upgrading service



User don't have to pay for the system, just pay fix rate energy fee.

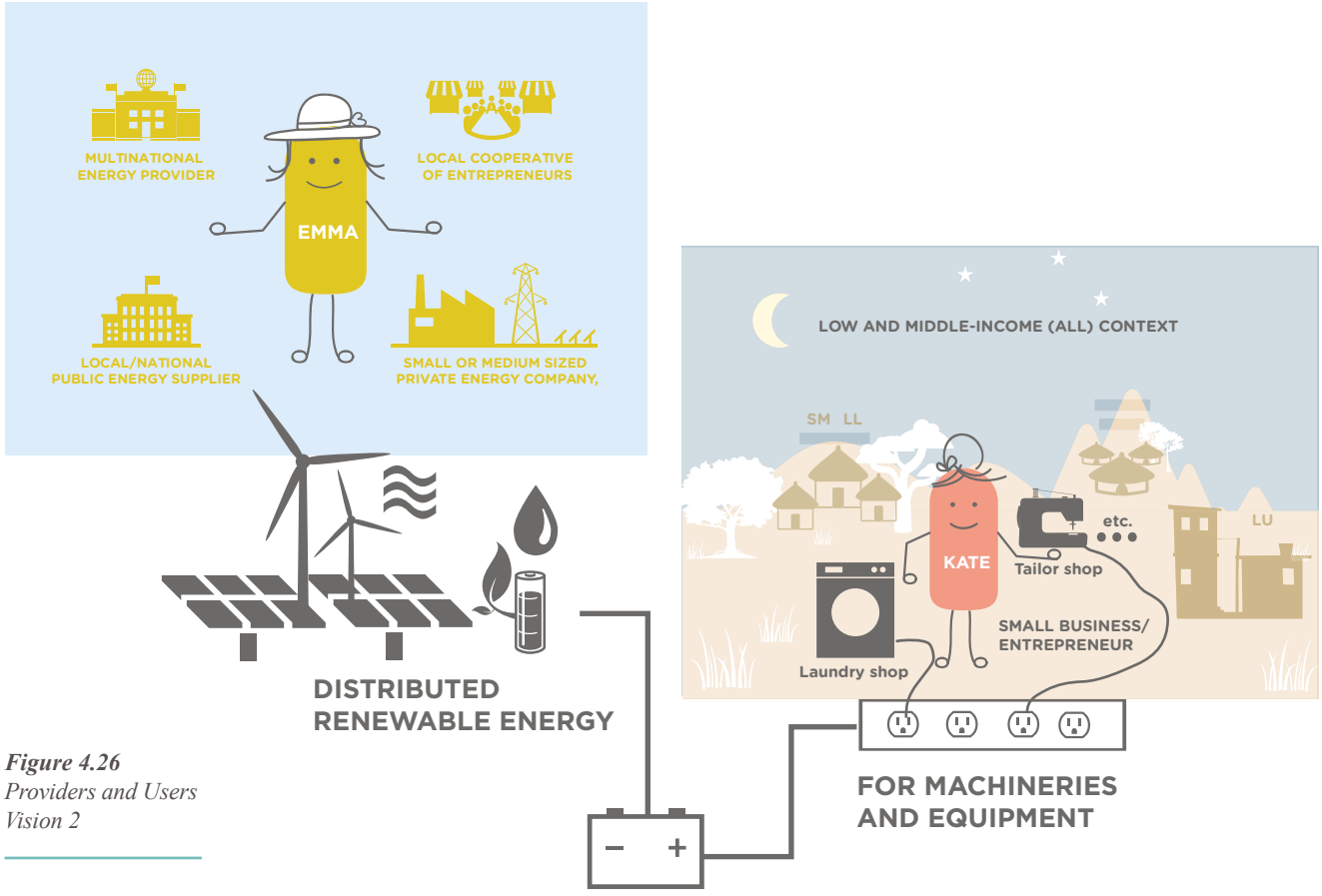
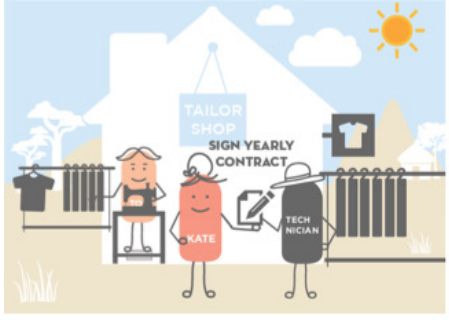
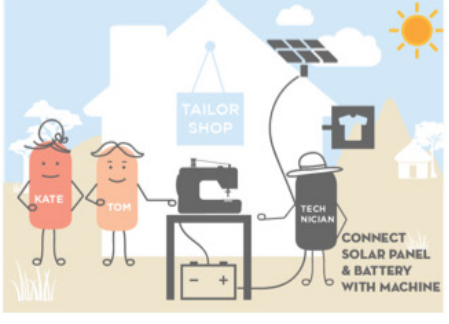


Figure 4.26
Providers and Users
Vision 2



After Kate decided to get service, she need to sign yearly contact



The sewing machine will be connected with solar panel and battery by technician

The bill will be sent to her place every months.

She can pay the same amount of energy fee at the shop nearby

From now on, they can work more productive with 2 sewing machines by solar energy

All day and night without the problem of unstable power supply from the main grid

VISION 2

Sub Video3 : Why the service is sustaianble?

Social-Ethical Sustainability

Improve employment/working conditions

The shop owner can work longer hours and more productive with distributed renewable energy (electricity) for machineries and equipment instead the pedal or manually powered sewing machine.

Empower/valorise local resources

Solar is energy could be the solution to provide electricity to the machine without connected to the unstable main grid because solar energy is available everywhere and it is free. Local resource can be created a lot of product identity in the small communities.

Favour/integrate the weaker and marginalized

After a certain age or if you are not full physically healthy using electric sewing machine you can still working.

Environmental Sustainability

System life optimization

the provider offer ownerless micro generator to machineries for small business, taking care of installation and maintenance and repairing doing so the micro gen system that could be last longer and be more efficient.

Resource reduction

Small entrepreneur can use distributed renewable energy of micro generator with existing machineries to run the business. As a resulted in reduction of the energy consumption from the main grid.

Conservation/biocompatibility

Increase the utilization of passive energy resources such as solar power especially to connect with the machineries or equipment of small entrepreneur.

Economical Sustainability

Long term business development

DRE service also consider long term cost saving for the small entrepreneur by improving the energy system for the machineries and equipment in order to be save long term cost and effective for local economic growth.

Profitability/ added value for companies

Small entrepreneurs are offered DRE micro generator to connect with any kind of machines to business without investment cost of the system and reduce the cost of electricity by paying the fix rate per period

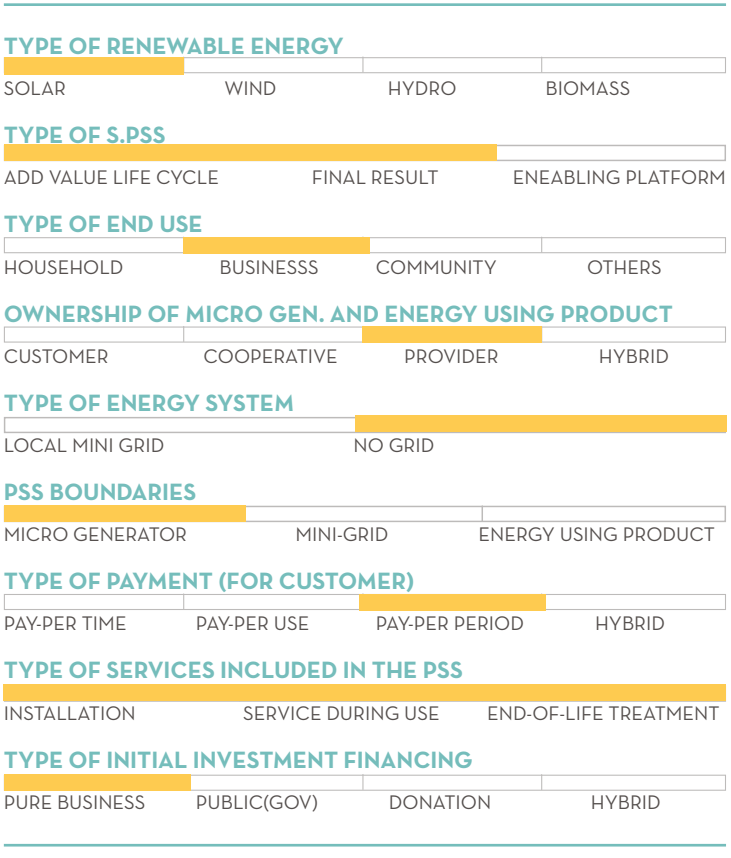


Figure 4.27
S.PSS Key characteristic Vision 2

VISION 3 : **"PAYxUSE" YOUR ACCESS TO DAILY LIFE PRODUCTS AND ENERGY**

Single users and small communities acquire an ownerless package of a Distributed Renewable Energy system + a set of energy using products for daily life, paying them per use

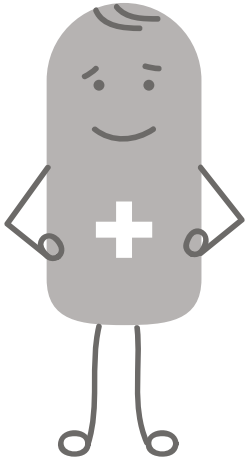
In the small village without access electricity. Meal are prepare by using firewood because the cost of LPG gas is very expensive. Mary and Ryan (her son) have to use fuel wood from far away, and smoke from burning wood is a toxic to kill them.

One day Ryan got sick, Mary send him to the hospital. Doctor said that because he got too much smoke and the toxic of burning wood. Last week, doctor got flyer about solar cooking. Probably it will be useful for them to avoid the use for fuelwood. Using solar energy is a good idea for cooking because it's clean safe and harmless.

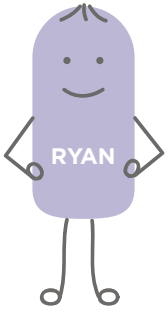
He said pilot project, a partnership between energy supplier and kitchen appliance offer cooking service with solar energy. in next month, fortunately there is also the village of Mary. They launch "solar home cooker" as a full package and "solar co-cooking space" as a platform in community area. Both service system is owned by providers, they will taking care of installation, maintenance. Users just "Pay per cook"

The first time, users need to buy pay per cook card at the shop, and add credit with the machine in the community kitchen. Just put the time duration and function, put the card into the slot, and get the energy for cooking. This card can use either solar home cooker and community kitchen if the want to cook with neighbors and friends.

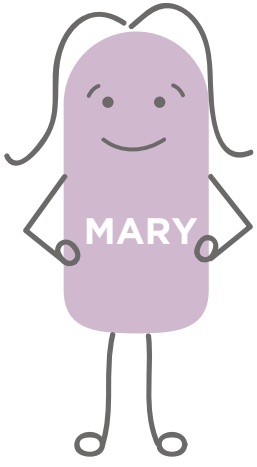
after one week, Ryan feel better because use the solar energy for cooking without the toxic of burning wood, Every last weekend of the month, villagers can join the eating and cooking together at the common kitchen. This service can improve the relationship, health and security of local people.



This is doctor, He is working in the hospital in the rural poor village.



Ryan is Mary's son. He is 5 years old. Ryan usually help mom to cook meal.

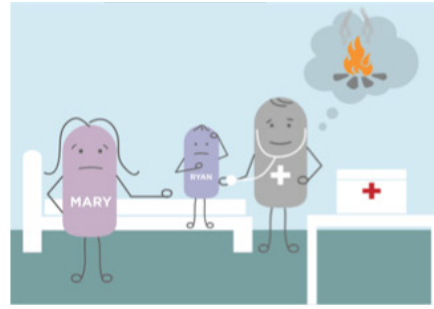


She is housewife who lives in the small village with and son (Ryan). She cooks meal everyday by using firewood

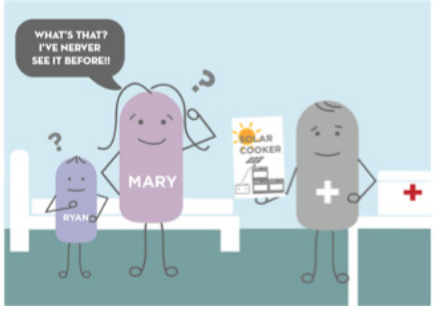
Figure 4.28
Personas Vision 3

In rural area, Mary and Ryan still using firewood for cooking meal

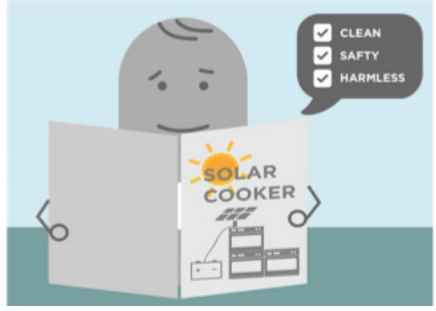
One day, Ryan got sick



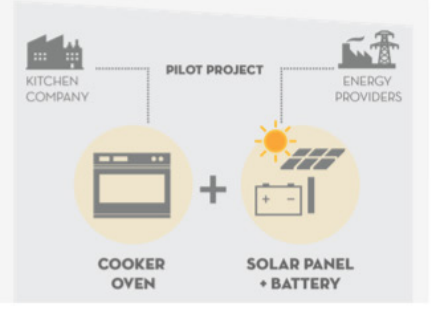
Doctor said that because of the toxic from smoke and burning wood, but Mary need it for cooking meal



Last week, doctor just got flyer about solar cooker, probably it will be useful.

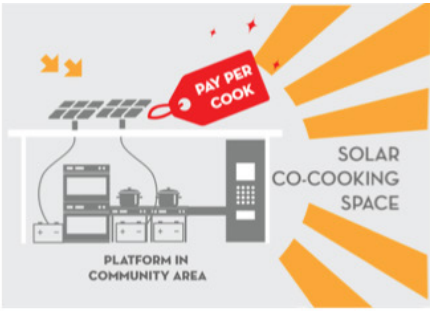


Using solar energy is great idea for cooking, it's clean, safety and harmless.



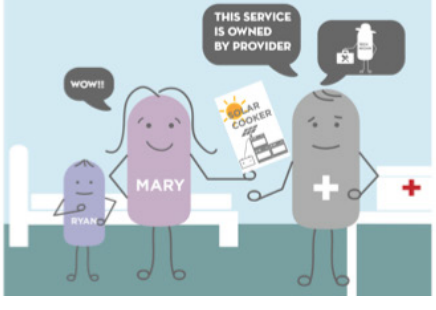
This is PILOT project, a partnership between kitchen company and energy supplier provides cooker and solar system

Launch “Solar home cooker” as a full package service



And “Solar co cooking space” as a platform in community area

Especially you just “pay per cook”!!



The services are owned by providers, also included installation, maintenance by technician

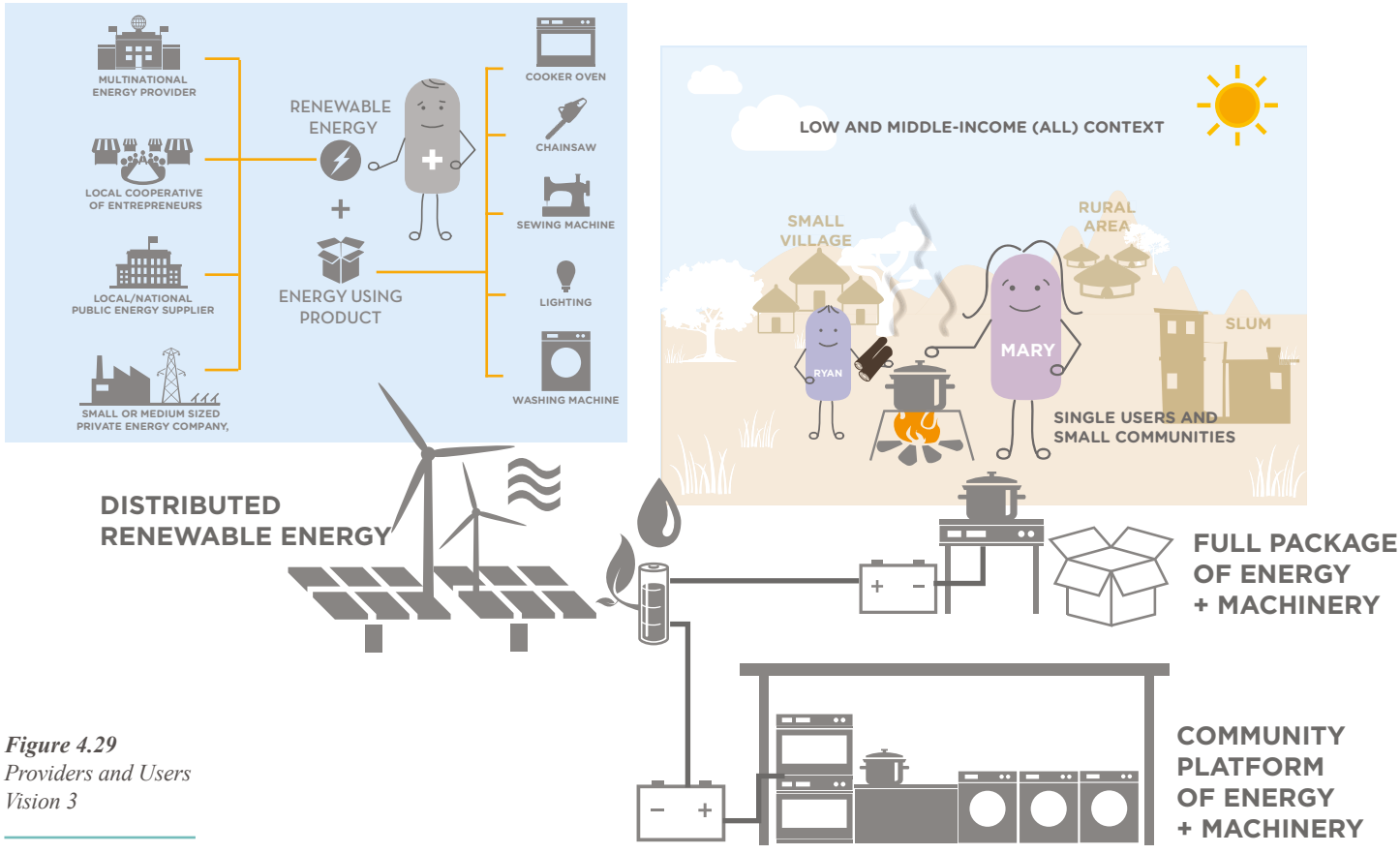
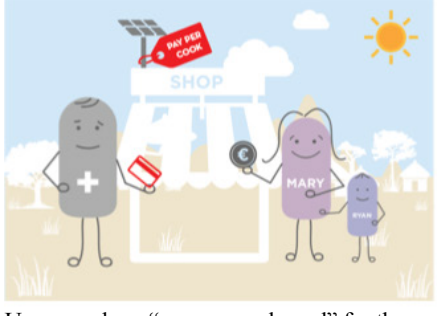
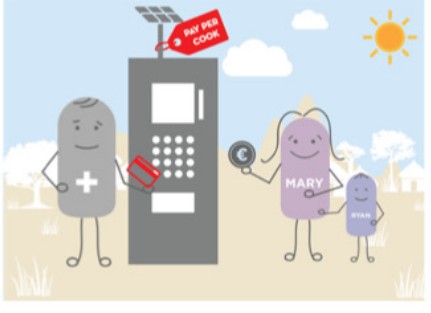


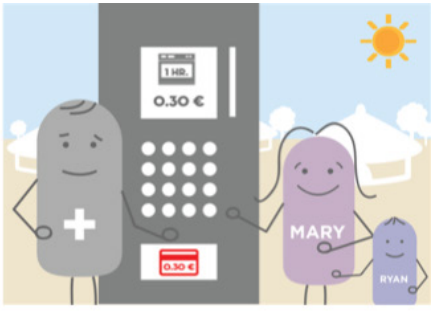
Figure 4.29
Providers and Users
Vision 3



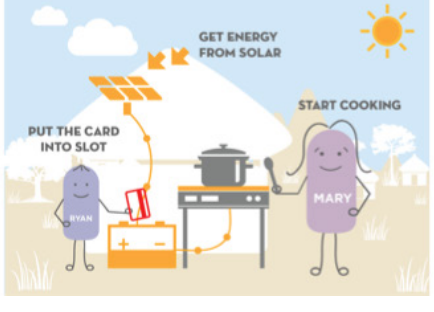
User scan buy "pay per cook card" for the first time at the shop



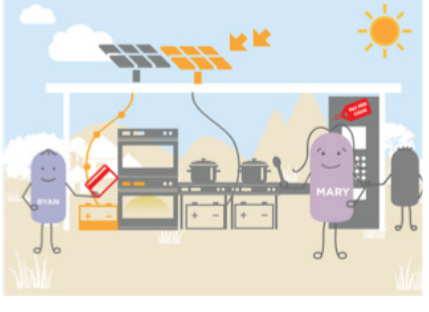
And add credit with the machine



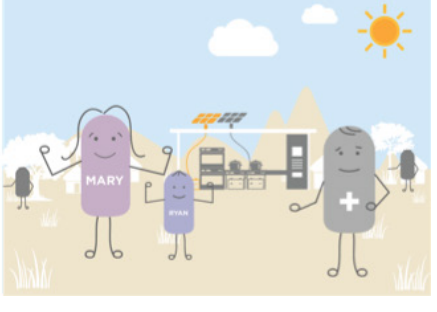
Choose function-time duration/ insert the coin /and get the card ready for cooking



Just put the card into slot, and then you can get solar energy



It can be used with solar co-cooking space as well



One week later, Ryan feel much better, thanks to the doctor for solar cooker that improve eating system for everyday meal

VISION 3

Sub Video3 : Why the service is sustaianble?

Social-Ethical Sustainability

Improve social cohesion
co-cooking space facilitates neighborhood, generation and gender social integration: to share a common kitchen from solar energy. Also increased participation and independence of local people

Favor/integrate the weak and marginalized
integrating people such as children, the elderly involving into the social context, developing systems to extend access to products and services to all social strata, developing systems of shared usage to increase their accessibility of basic facilities in daily life.

Environmental Sustainability

System life optimization
Energy supplier and the provider of kitchen appliances offer ownerless energy and appliance for cooking for single users and small communities, including installation and maintenance.

Toxic reduction
Reduce the toxic and smoke from burning firewood in the village. Improving health and security of eating system

Resource reduction
Using solar we avoid the high consumption of wood, charcoal which lead to desertification etc. and providing community solar cooker the kitchen appliances are shared and used by all the community.

Transportation reduction
Common kitchen for all can reduce the process of collecting and preparing fire wood for everyday cooking meal.

Economical Sustainability

Partnership/ Cooperation
The partnership between energy supplier and kitchen company could create pilot project to improve basic eating system from distributed renewable energy These will pave the way for expanding this project in order to become an economic feasibility business model to many villages in low and middle income contexts.

Add values for a customer
Users can cook meal with clean energy from solar power and cooker in affordable price by paying per time of use, add the credit in card for cooker full service and co-cooking space platform.

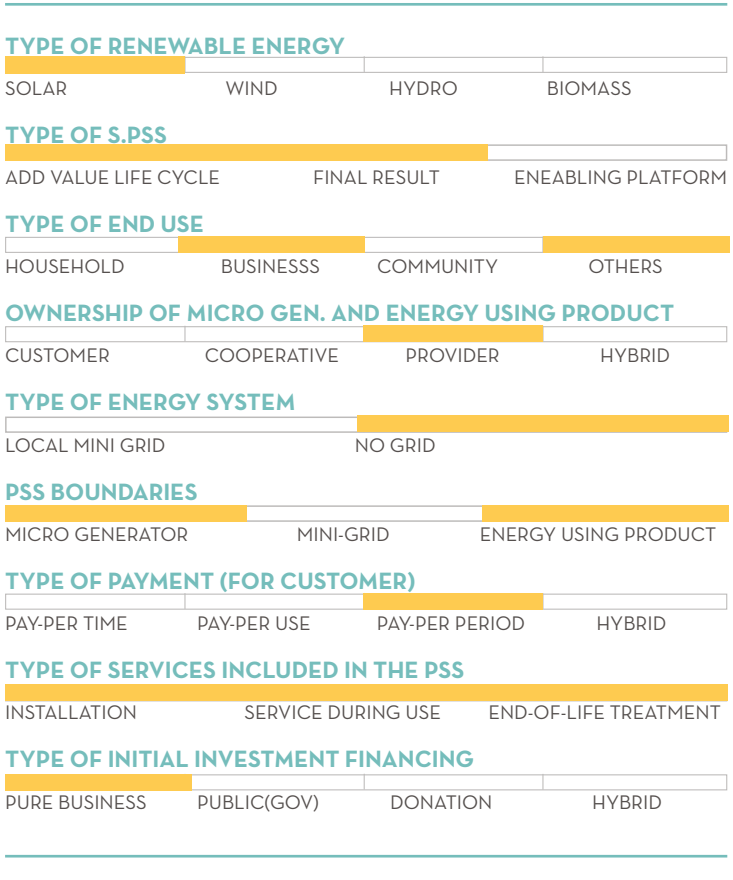


Figure 4.30
S.PSS Key characteristic Vision 3

VISION 4 : **START-UP YOUR BUSINESS PAYING X PERIOD EQUIPMENT & ENERGY**

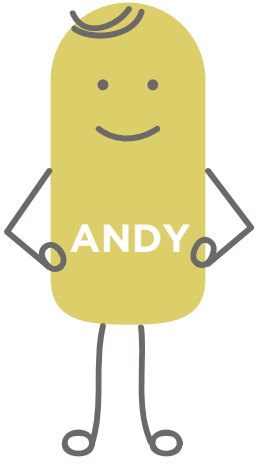
Single entrepreneurs acquire an ownerless package of a Distributed Renewable Energy system + the equipment to start-up a business

Ben is a local carpenter in the small village who has a good skill and big passion to produce wood product. He has a dream to use woodworking machine to improve his skill and make the local wood furniture business.

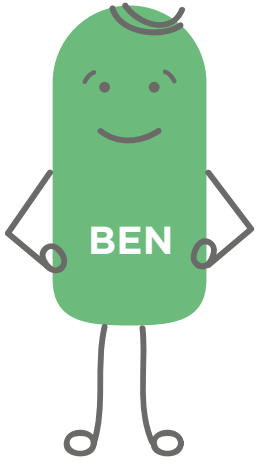
Ben try go to the local back, but without financial credit, he cannot get loan to buy the new machine. During the way back home, fortunately he found the startup business event with solar energy with out investment cost. he doesn't understand how the solar panel can work with machine, probably the cost is very high. Andy from the energy service company asked Ben goes to the shop to explain more in detail and see the real machine and system in the next day.

Andy explains the service, this is the small woodworking machine comes together with solar energy system and micro generator, free one week trial and training, also including full service; installation and maintenance service. If it's alright, making the contract for one year with fix monthly payment.

Ben can produce a lot of wood furniture and geo very good feedback from tourists because uniqueness and local made. After 6 months he sell his products to other villages. This solar + machine service changed his life to generate more incomes become a local entrepreneur in his hometown.



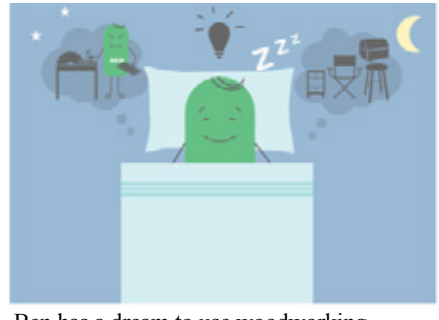
He is 23 years old. He is technician in the solar machine company.



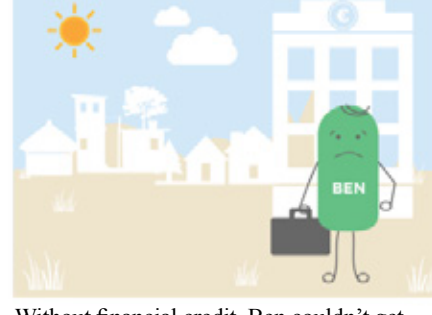
He is 20 years old, a local carpenter who has very good skill and passion about woodworking. he produces a lot of wood craft products. he dreams to have woodworking machine to produce wood furniture

Figure 4.31
Personas Vision 4

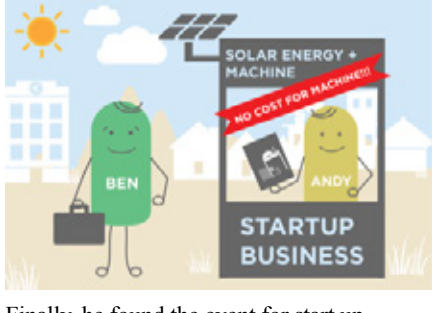
This is Ben, the local carpenter in the small village Who a big passion to make wood products



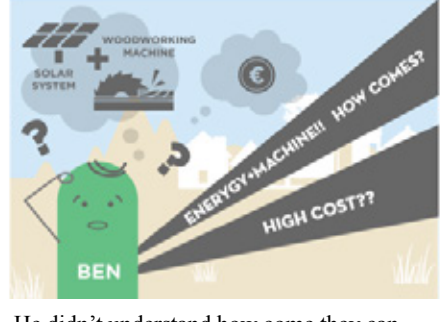
Ben has a dream to use woodworking machine to improve his skill and build the local wood furniture shop



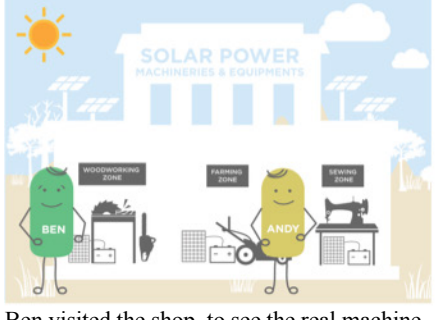
Without financial credit, Ben couldn't get bank loan for investment



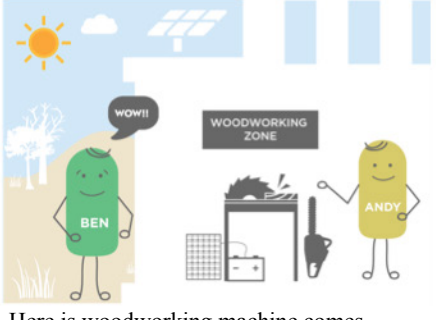
Finally, he found the event for start up business with energy and machine



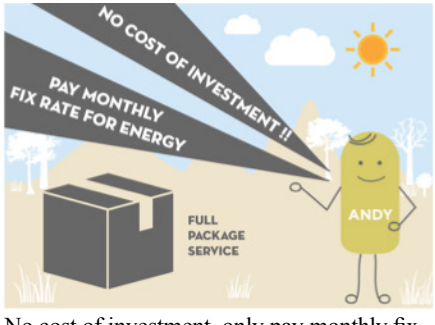
He didn't understand how come they can work together, machine and solar panel, probably the cost is very high



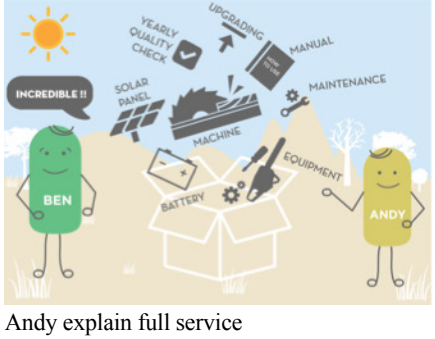
Ben visited the shop to see the real machine with solar energy



Here is woodworking machine comes together with micro generator of distributed renewable energy



No cost of investment, only pay monthly fix rate for energy



Andy explain full service
No cost of machine and solar system
Just pay monthly fix rate energy cost

You will get everything including full service

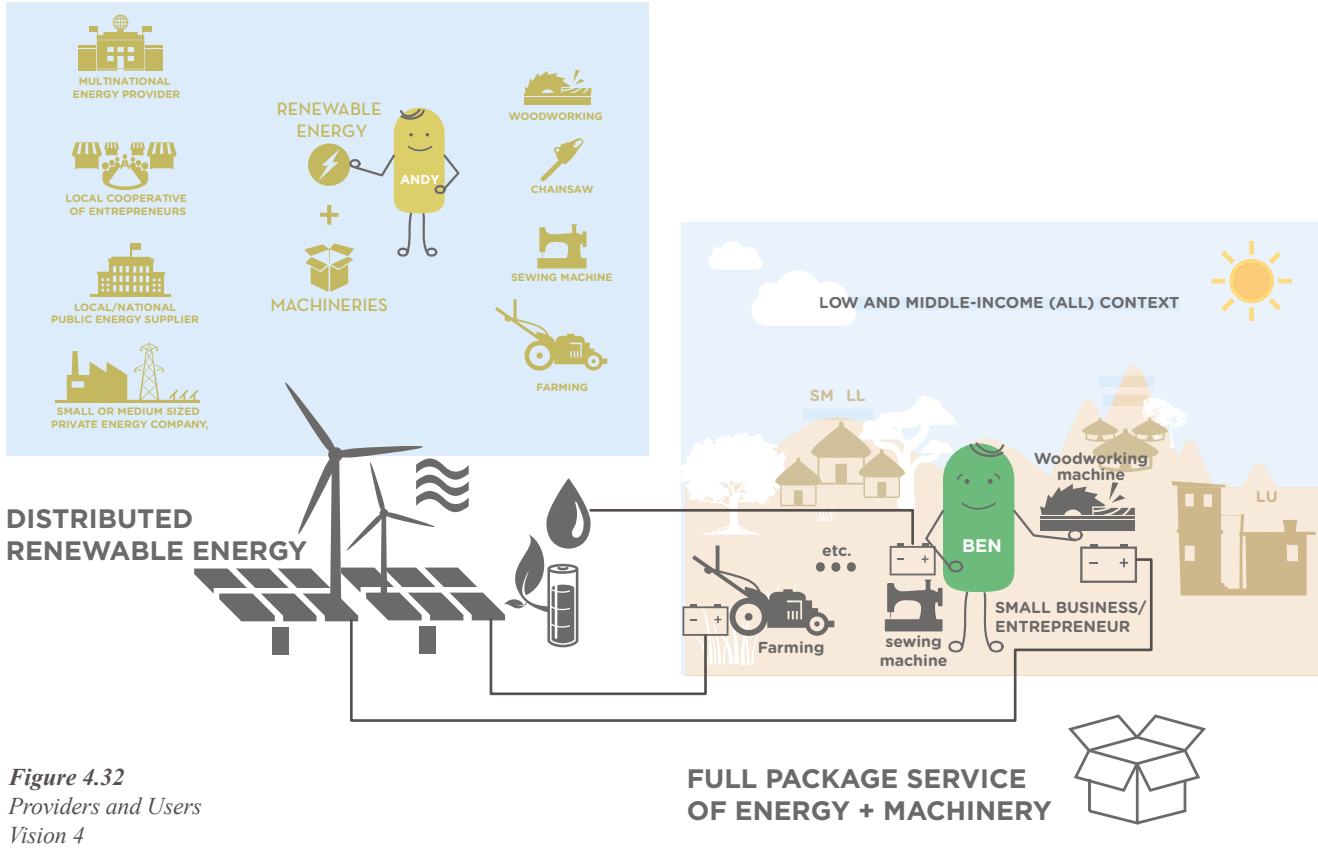
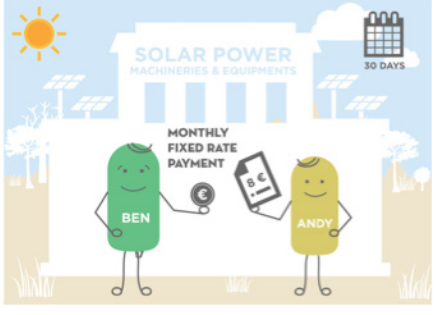


Figure 4.32
Providers and Users
Vision 4

After 7 days trial, Ben has to sign yearly contact



And pay fix rate monthly fee at the solar power shop

He got very good feedback from tourist because his product is uniqueness and local made. They can earn more money

This solar system and machine changed his life to become local entrepreneur in his hometown

VISION 4

Sub Video3 : Why the service is sustaianble?

Social-Ethical Sustainability

Improve employment/working conditions

To increase their business opportunities, working conditions and startup their business. If they have a professional skill, this full package could help them to improve the skill and become an entrepreneur without investment cost of machine and energy system.

Empower/valorise local resources

Local resource such as wood can be created a lot of identity products (local souvenir) by local people in order to generate more incomes. And also create local business, reduce the migration to cities to look for job opportunities.

Environmental Sustainability

System life optimization

Energy supplier and the provider of machines and equipment offer ownerless package of energy and machine for startup business for small entrepreneur, including installation and maintenance. The system is going to be last longer and be more efficient

Resource reduction

Offering ownerless full package of product and energy included installation maintenance and upgrade service through payment based on a periodical with long term contract
from the main grid

Transportation reduction

To encourage local entrepreneur to create local products in term of reduction the transportation of import goods form outside villages.

Economical Sustainability

Long term business development

Empowering local economic growth by supporting locally made and marketed products from small village that could help to generate many incomes for local people.

Profitability/ added value for companies

Single entrepreneurs are offered package of DRE micro generator with any kind of machines to start up business without investment cost of the system and reduce the cost of electricity.

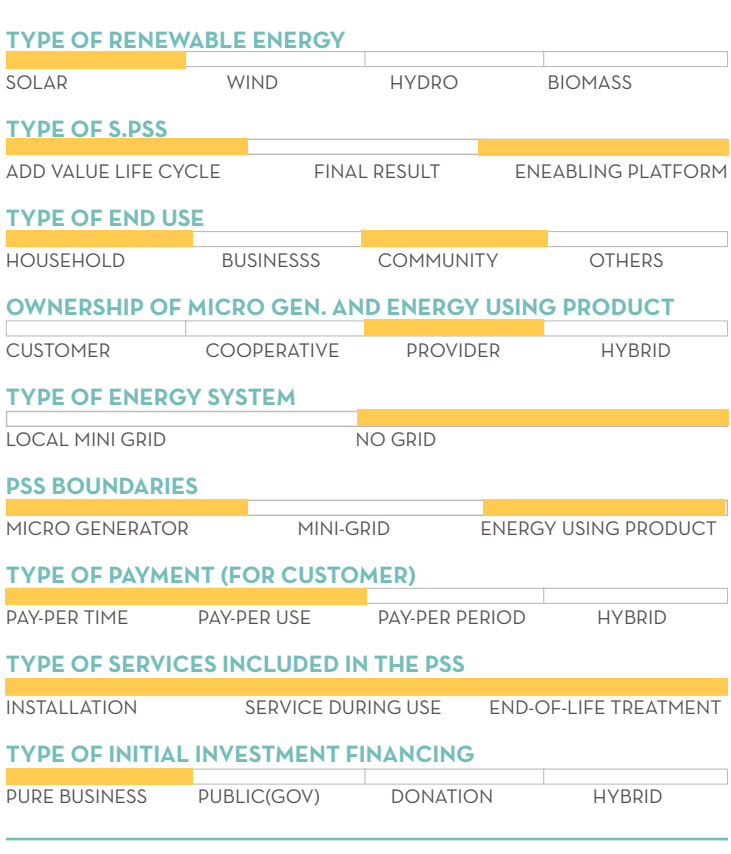


Figure 4.33
S.PSS Key characteristic Vision 4

5.

CONCLUSION

1

PROJECT CONSIDERATION

1.1. SWOT ANALYSIS

The SWOT analysis is a valid tool to understand the strengths, weaknesses, opportunities, and threats involved in a project, so it can be a useful tool to evaluate design projects too. The following SWOT analysis has been done with a focus on the Sustainable 4 visions to show the possible and promising so call Sustainable Design-Orienting Scenario can represent a challenge, positive and negative.

The Sustainable Design-Orienting Scenario (SDOS) could bring new opportunities to enlarge and improve the S.PSS, applying in the low and middle-income context of Distributed renewable Energy both users and providers that can take advantage in term of business and daily life activities. The 4 visions are represented the idea with micro generator of DRE that remain the ownership by provider (without investment and initial cost for the system) with affordable payment for users in all contexts. This is the main key point of Sustainable product-service system.

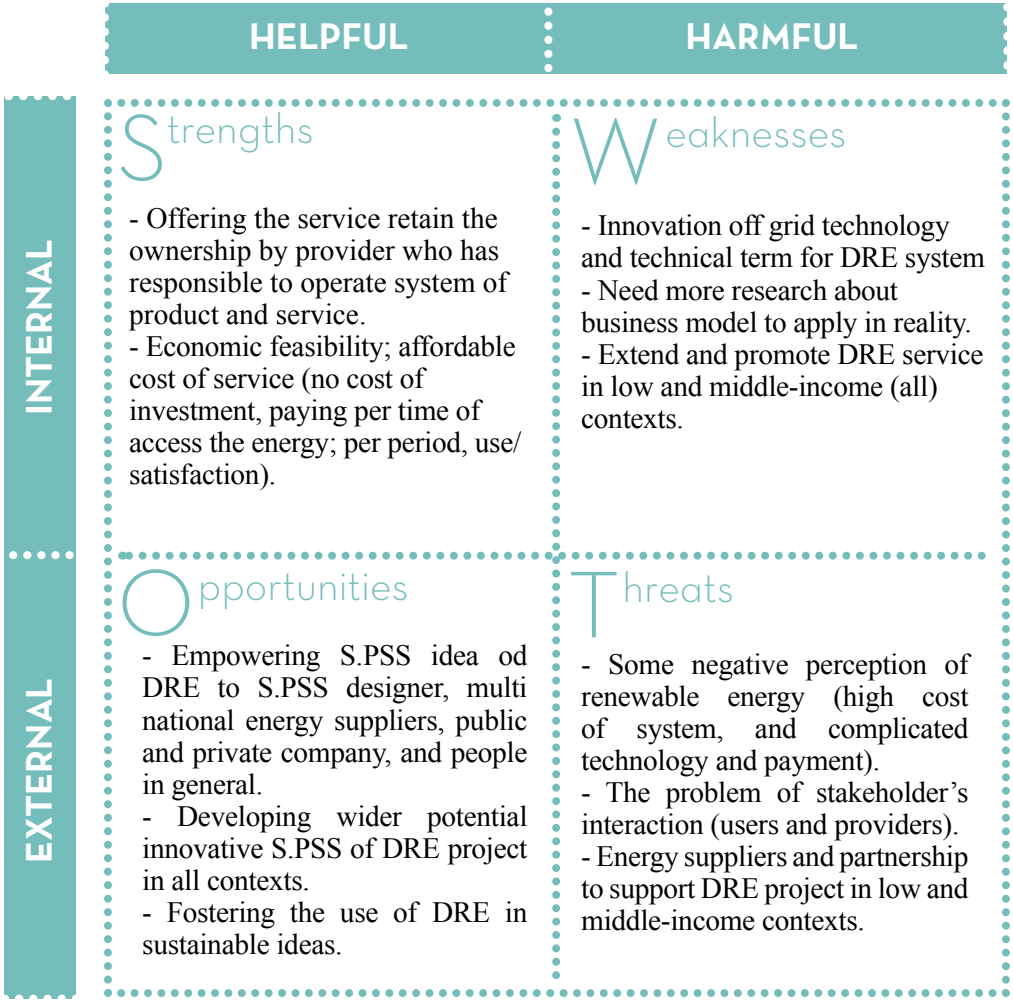


Figure 4.8
SWOT analysis

1.2. FUTURE IMPLEMENTATION

1. Micro generator of distributed renewable energy system for housings of and business with the solar panels would be connected to the grid and could exchange energy between them and the other dwellings. User is required to regulate the production and transfer of energy from the single households to the public grid and to the energy supplier that could earn more income from generate power.

2. This scenario will be presented the short movie for each vision that could be the starting point to create the DRE video platform to collect and provide the video link of renewable energy from digital resources in the LeNSes project (the Learning Network for Sustainable energy systems, www.lenses.polimi.it). It could be useful as a tool provide information and ideas for S.PSS designer, Energy providers and customers

1.3. CONCLUSION

Nowadays fossil energy use is associated with a number of negative environmental effects. Renewable energy will be a key part to reduce emissions of climate-changing greenhouse gases and other pollution. As a result, renewable energy technologies, particularly, solar power, are the fastest growing sources of electricity Furthermore, environmental and security concerns have sparked increased interest in small-scale, “distributed” sources of renewable electricity generation like rooftop solar panels for individual homeowners and small business owners

The role of distributed renewable energy has increased the accessibility of electricity. The aim is giving access to “Sustainable Energy for All” fostering sustainable development, based on promising models of Sustainable Product-Service System (S.PSS) and Distributed Renewable Energy (DRE) with economical feasible and affordable price of energy that would help greatly improve their quality of life, health and security in low and middle-income contexts.

Our visions represented by the combination of two polarity axes in which related to the category of customer (B2C; final customer and B2B; a small entrepreneur) and the configuration of distributed renewable energy (micro generator and energy using product). In this scenario could be changed the perception of renewable energy for people in general. Most of them thought that renewable is high cost of the system, advance technology, and difficult for maintenance. Each vision will be presented by short movie to explain the possible of Sustainable Product-Service System (S.PSS) and Distributed Renewable Energy (DRE) that could be applied even in low and middle-income (all) contexts.

2 REFERENCE

2.1. BIBLIOGRAPHY

Ceschin F., *Introduction and scaling-up of sustainable Product Service Systems: A new role for strategic design for sustainability*, Phd DesignThesis, Politecnico di Milano (2012)

Colombo E., Bologna S., Masera D. *Renewable Energy for Unleashing Sustainable Development*, Springer International Publishing Switzerland. (2013)

Cortesi S., Vezzoli C., Donghi C. (2010). *Case study of the design of Eco-Efficient Product-Service-System for KONE Corporation, using the MSDS method and tools*. In Ceschin F., Vezzoli C., Jun Z. (a cura di), Atti Sustainability in Design: Now! Challenges and Opportunities for Design Research, Education and Practices in the XXI Century. Greenleaf Publishing Inc, Sheffield, 2010

Rifkin J. *The Third Industrial Revolution. How Lateral Power is Transforming Energy, the Economy, and the World*. New York: Palgrave Macmillan. (2011)

Tenenbaum B., Greacen C. , Siyambalapitiya T. , and Knuckles J., *From the Bottom Up; How Small Power Producers and Mini-Grids Can Deliver Electrification and Renewable Energy in Africa.* The world bank, Washinton D.C., (2014)

UNEP and TUDelft, Design for Sustainability: a practical approach for developing economies, (2006)

Vezzoli C., Kohtala C., Srinivasan A., with Xin L., Fusukal M., Sateesh D. and Diehl J.C. *Product-Service System Design for Sustainability*, Sheffield, UK: Greenleaf Publishing. (2014)

Vezzoli C., Cortesi S., Santos A., Ceschin F., *The Eco-Efficient Design Orienting- Scenario*, KONE, (2009)
Vezzoli C., Manzini, E., *Product-Service Systems and Sustainability: opportunities for sustainable solutions*, UNEP, (2012)

Vezzoli C., System design for sustainability: a promising approach for emerging low-income contexts.

Vezzoli C., Manzini E. (2008) Design for environmental sustainability. Patronised

Vezzoli C. (2010) System design for sustainability. Theory, methods and tools for a sustainable "satisfactionsystem"design. Second edition, Patronised United Nation (DESD), Maggioli editore, Rimini (secondedition).

2.2. DIGITAL DOCUMENTS

Dienst C., OrtizW., Pfaff J., Vallentin D., *Access to electricity ;Technological options for community-based solutions*. Wuppertal Institute for Climate, Environment and Energy (2010)

Dienst C., OrtizW., Pfaff J., Vallentin D., *Food issues; Renewable energy for food preparation and processing*. Wuppertal Institute for Climate, Environment and Energy (2011)

Dienst C., OrtizW., Pfaff J., Vallentin D., *Lighting; Energy efficient lighting for sustainable development*. Wuppertal Institute for Climate, Environment and Energy (2013)

SolarWorld, *Sunmodule for off-grid solution*, www.solarworld.com, (2010)

The Rockefeller Foundation ., *Smart Power for Environmentally Sound Economic Development (SPEED)*. www.rockefellerfoundation.org

UNEP, Financing renewable energy in developing countries (2012)

Vezzoli C., Delfino E. and Ambole L., *System design for sustainable energy for all. (*2014). www.FORMakademisk.org.

2.3. WEBLIOGRAPHY

http://www.lens.polimi.it/
http://www.lenses.polimi.it/
http://www.sdo-lens.polimi.it/
http://lezione.sdo-lens.polimi.it/
http://www.slideshare.net/LeNS_slide/
http://www.designtango.eu/
http://www.ashden.org/
http://www.wisions.net/
http://niceartlife.com/south-african-townships-solar-powered-cafe/
http://www.rockefellerfoundation.org/our-work/current-work/smart-power-india
https://joinmosaic.com/
https://solar-aid.org/
http://www.littlesun.com/
http://gravitylight.org/the-challenge/
http://eight19.com/overview/indigo-pay-you-go-solar
http://www.sustainableenergyforall.org/resources.
http://www.nemgen.org.uk/index.php?page=nemgen-microgeneration
http://www.oilgae.com/ref/glos/renewable_energy_micro_generation.html
http://www.creativemove.com/architecture/mobile-internet-cafe-in-africa/
http://www.gracelinks.org/2687/distributed-renewable-energy-systems-
https://vimeo.com
https://www.youtube.com/

2.4. CONSULTED THESIS

Bacchetti, Elisa. ShareRadio, (Ex)Change your time: A sustainable PSS, focused on intergenerational dialogue. Part of the TANGO EU funded project. Tutor: Carlo Vezzoli, Politecnico di Milano, 2012.

Delfino, Emanuela e Remotti, Silvia. Sunride: design and implementation of a sustainable mobility PSS in Cape Town.
Tutor: Carlo Vezzoli, Politecnico di Milano, 2010.

2.5. LIST OF FIGURES

PART 1

PART 2

PART 3

PART 4

2.6. LIST OF TABLES

THANK YOU

I wish to dedicate this thesis to my ***Prof. Carlo Vezzoli***
and ***LeNSes Project*** *(the Learning Network on Sustainable energy systems).*
I hope it would be useful as tools base on sustainable energy for all.

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