

# SUSTAINABLE ENERGY FOR ALL BY DESIGN

Edited by Emanuela Delfino and Carlo Vezzoli

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## **Sustainable Product-Service System (S.PSS) applied to Distributed Renewable Energy (DRE) in low and middle income (all) contexts: a Scenario tool for designers**

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### **ABSTRACT**

In the framework of the Sustainable Energy for All decade (United Nations, SE4All 2014-2024), the LeNSes project - the Learning Network for Sustainable energy systems, (Edulink II programme, EU funded - 2013-2016) aims at develop and disseminate in African and European Higher Education Institutions an emerging design discipline: System Design for Sustainable Energy for All (SD4SEA), where the focus is the approach of Sustainable Product-Service Systems Design for sustainable energy for All.

The paper presents the Scenario tool, within the SD4SEA discipline, aimed at inspire and inform designers and design students, through new visions of Sustainable Product-Service System (S.PSS) as promising model to diffuse Distributed Renewable Energies (DRE) in low and middle-income contexts (Research Hypothesis of the LeNSes project). The paper introduces the Scenario contents and design process; as well as the experiences using the Scenario during pilot, curricular and lifelong learning courses of the LeNSes project.

Key Words: Scenario; Sustainable Product-Service Systems (S.PSS); Distributed Renewable Energies (DRE).

## 1. The System Design for Sustainable Energy for All (SD4SEA) emerging discipline

The Learning Network on Sustainable energy systems - LeNSes EU funded project (Edulink II, 2013-2016, [www.lenses.polimi.it](http://www.lenses.polimi.it)), that involves four African and three European universities of design<sup>41</sup>, is an African-European multi-polar network of HEIs aiming at curricula development on System Design for Sustainable Energy for All (SD4SEA), i.e. to favour the building up of a new generation of practitioners capable of extending the access to locally-based, secure and cleaner energy services, based on the promising models of Sustainable Product-Service Systems (S.PSS) and Distributed Renewable Energy (DRE), addressing equity and gender issues.

During the three years of the project the System Design for Sustainable Energy for All (SD4SEA) emerging discipline, have been developed, as source of new knowledge and know-how for designers, design educators and students dealing with Sustainable Energy for All. In fact, the System Design for Sustainable Energy for All discipline promotes a *'stakeholder configuration'* approach, which means designing the interactions of the stakeholders in a particular satisfaction-system, combined with a *'system sustainability & energy 4 all'* approach; meaning to design stakeholder interactions (the offer model), which for economic and competitive reasons continuously seek both socio-ethical and environmentally beneficial new solutions that are powered by a distributed renewable energy system accessible to All. This discipline has been defined as *"the design of a Distributed Renewable Energy system of products and services, able to fulfil the demand of sustainable energy of low and middle-income people (all) - possibly including the supply of the Energy Using Products/Equipment system - based on the design of the innovative interactions of the stakeholders, where the economic and competitive interest of the providers, continuously seeks after both socio-ethically and environmentally beneficial new solutions"* (LeNSes project, 2016).

Along the LeNSes project, within the System Design for Sustainable Energy for All discipline, a series of tools have been designed and experienced. Those are now available for free on the LeNSes project website [www.lenses.polimi.it](http://www.lenses.polimi.it) (tool section). In the section below, the Scenario, one of the tools, is introduced.

## 2. The Scenario: structure, contents and design process

The Scenario has been developed (more details on the design process in section 2.2) to show a new picture of sustainable production & consumption systems characterized by the application of the promising model of *Sustainable Product-Service System (S.PSS) applied to Distributed Renewable Energy (DRE)* in low and middle-income contexts<sup>42</sup>, and is designed to inspire the design of sustainable energy solutions. The Scenario is composed by four visions, each representing a Sustainable win-win configuration; combining socio-cultural, organizational 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.

### 2.1 Structure and contents of the Scenario

The Scenario frames its four visions within two polarity axes. The horizontal axis shows the relation with the customer: as final user (B2C) on one pole (left), or as small entrepreneur/small business (B2B) on the other (right). The vertical axis presents the offer: on one pole (top), as a Distributed Renewable Energy micro-generator (e.g. solar panel system plus its components such as storage, inverter, wires, etc.) and, on the other pole (bottom), as the sum of both the Distributed Renewable Energy micro-generator and the related Energy Using Products or Energy Using Equipment (e.g. phone and television are Energy Using Products; woodworking machine, sewing machine are Energy Using Equipment).

Four quadrants, as intersection of the two axes, present the following four visions:

Vision 1: Energy for all in daily life

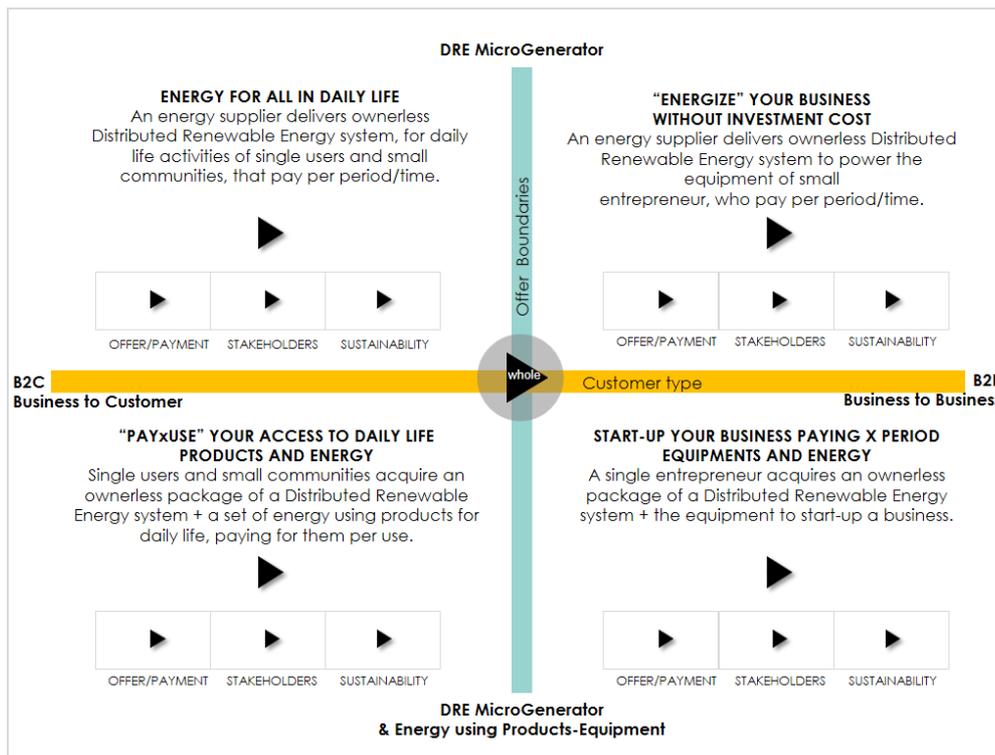
Vision 2: Energize your business without initial investment cost.

Vision 3: 'Pay x use' for your daily life products and energy.

Vision 4: Start-up your business paying per period for equipment and energy

<sup>41</sup> LeNSes partners: Cape Peninsula University of Technology (South Africa), Makerere University (Uganda), University of Botswana (Botswana), University of Nairobi (Kenya), Brunel University (United Kingdom), Delft University of Technology (the Netherlands).

<sup>42</sup> The Scenario purpose, derives from the Research Hypothesis of the LeNSes project that: 'Sustainable Product-Service System (S.PSS) model applied to Distributed Renewable Energies (DRE) is a promising approach to making sustainable energy accessible to all'

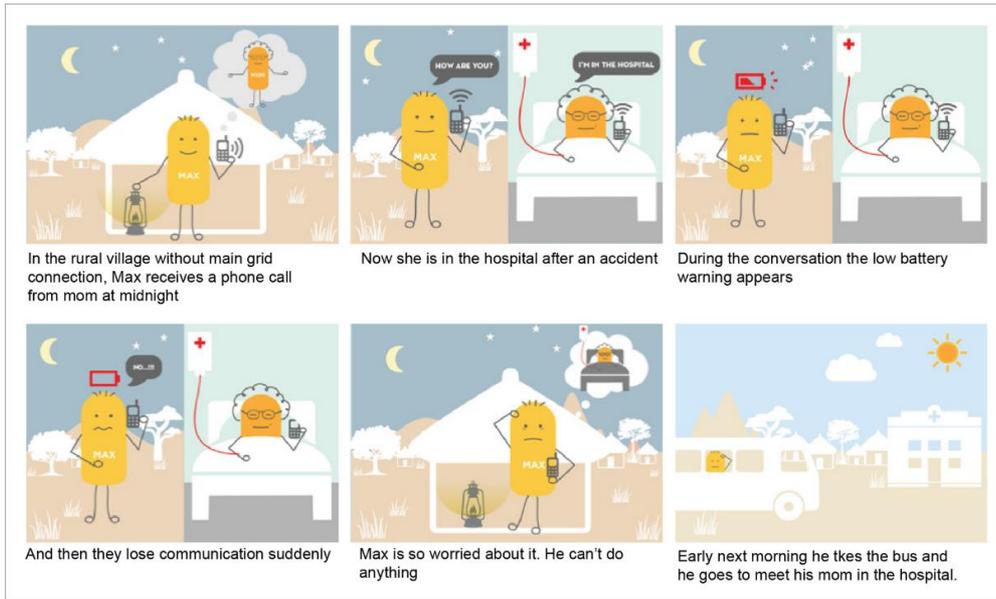


[Figure 1] Scenario (visions navigator-interactive file)

Below a short description introduces each Vision of the Scenario.

Vision 1: Energy for all in daily life (quadrant 1), presents a business to customer (B2C) offer of a Distributed Renewable Energy (DRE) micro-generator, where *‘an energy supplier delivers an ownerless Distributed Renewable Energy system, for daily life activities, to single users and small communities who pay per period/time.’* In this vision the ownership of Distributed Renewable Energy micro-generator and its components (e.g. solar panel, wires, storage) stays with the energy supplier. This cuts for the customer, both initial investment cost (e.g. the purchase of solar panel, wires, storage and their installation) and life-cycle costs (e.g. maintenance and repair) covered by the energy supplier. Instead, the customer makes periodic payments, which are more customizable and affordable. This configuration makes access to energy economically affordable even in low-middle income contexts, so that the quality of life could be greatly improved, especially in relation to health and security.

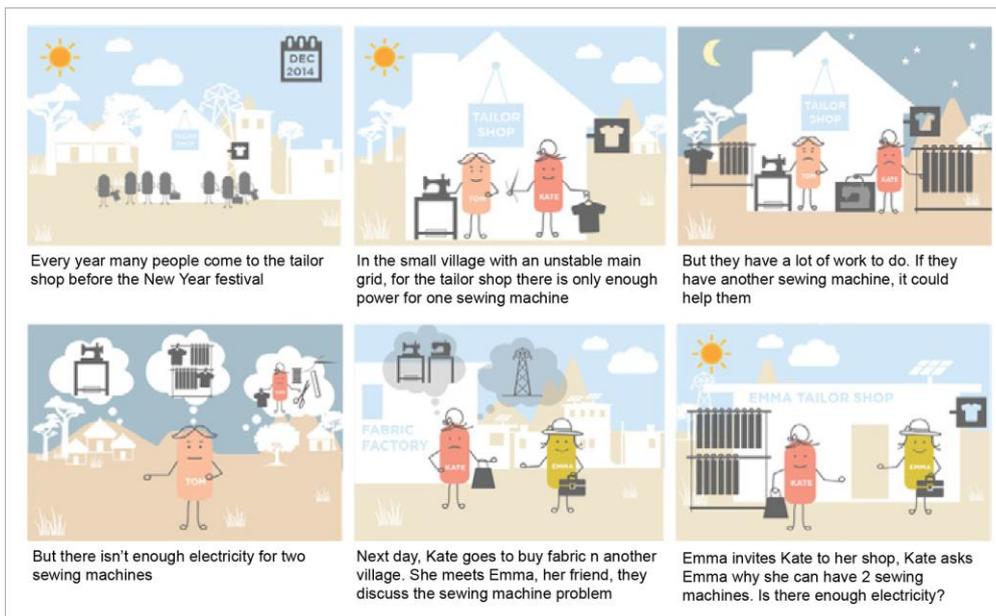
The figure below shows the narration of vision 1 (many other could be imagined): *‘Max doesn’t have to buy the Distributed Renewable Energy micro-generator and its components; he just uses them by paying per period a fixed amount of money. Ownership and related services remain with the energy supplier, who is interested in reducing maintenance and repair needs, improving his own profit while reducing the environmental impact of the system.’*



[Figure 2] Screenshots from the video 'Energy for all in daily life', by Korapan Vanitkoopalangkul. Text is given by voice narration.

Vision 2: Energize your business without initial investment cost (quadrant 2), shows a business to business (B2B) offer of a Distributed Renewable Energy micro-generator, where “an energy supplier delivers an ownerless Distributed Renewable Energy system to power the equipment of a small entrepreneur, who pays per period/time.” In this vision, as in the previous one, the Distributed Renewable Energy micro-generator and related components are not owned by the customer. This reduces risks for small entrepreneurs or businesses (customers in the vision), who don't have to face any initial investment, except for the purchase of the necessary Energy Using Equipment (e.g. sewing machine for the tailor shop) to start-up or upgrade their small enterprises/businesses. In this way, a small entrepreneur/business even in low-middle income contexts, who receives a stable energy access, will be able to guarantee the production/delivery of a predetermined quantity of products/services within a given time, thus satisfying its clients and opening new market opportunities.

The figure below shows the narration of vision 2: “Kate and Tom are tailors in a rural village. They have no stable access to Energy, so they still use a diesel generator to power their sewing machine. If they can access a solar system installed in their tailor shop, guaranteeing secure energy access, they can guarantee on time delivery and avoid losing clients.”

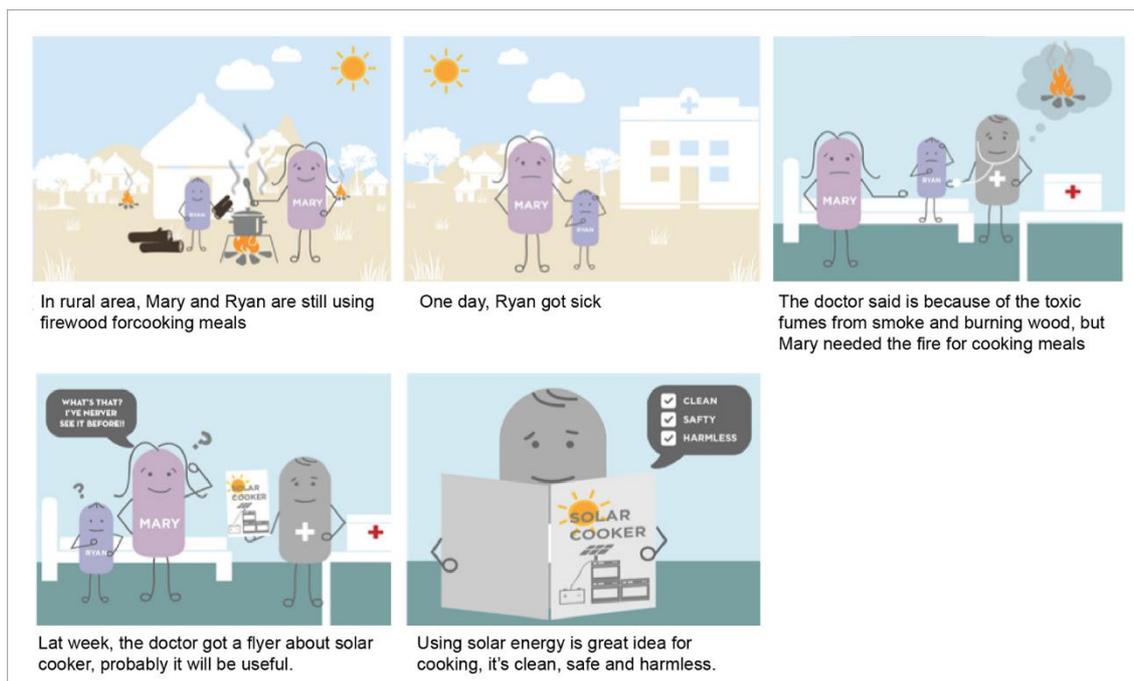


[Figure 3] Screenshots from the video Energize your business without investment cost, by Korapan Vanitkoopalangkul. Text is given by voice narration.

Vision 3: "Pay x use" your daily life products and energy (quadrant 3), presents a business to customer (B2C) offer of a Distributed Renewable Energy (DRE) micro-generator (and the related components) plus related Energy Using

Products. The vision is titled "Pay x use" your daily life products and energy, where *"Single users and small communities acquire an ownerless package consisting of a Distributed Renewable Energy system plus a set of energy using products for daily life, paying for them per use."* In this vision, as in the previous two, the Distributed Renewable Energy micro-generator and related components are owned by the energy supplier. In this case, the Energy Using Products (e.g. burner, oven, etc.) are included in the ownerless offer for the customer. This configuration cuts the initial investment cost (e.g. purchase, installation) of both Distributed Renewable Energy micro-generator and Energy Using Products, as well as their life-cycle costs (e.g. maintenance and repair). For many people still using firewood for cooking, energy access could greatly improve their quality of life, reducing diseases caused by toxic emissions from the fire.

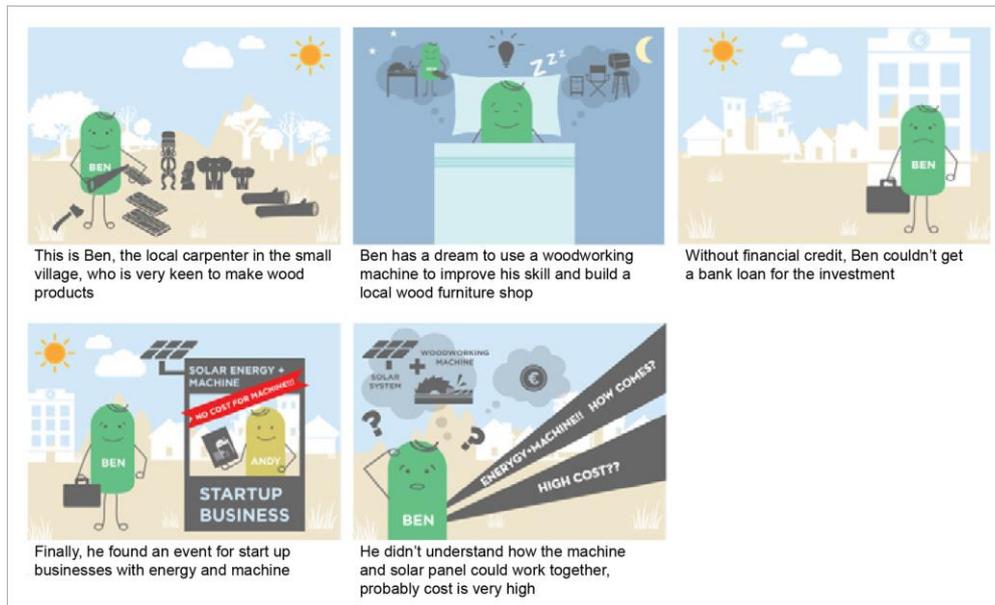
The figure below shows the narration of vision 3: *'Mary and Ryan, are a family living in a rural village where cooking with firewood is still the main solution. If they can have a solar system installed on their roof, guaranteeing secure energy access, they can reduce health risks, while gaining time no longer needed for firewood collection.'*



[Figure 4] Screenshots from the video 'Pay x use' for your daily life products and energy, by Korapan Vanitkoopalangkul. Text is given by voice narration.

Vision 4: Start-up your business paying per period for equipment and energy (quadrant 4), is identified as a business to business (B2B) offer of a Distributed Renewable Energy (DRE) micro-generator (and the related components) plus Energy Using Equipment, where: *'a single entrepreneur acquires an ownerless package, consisting of a Distributed Renewable Energy system plus the equipment to start-up a business.'* In this vision, a small entrepreneur/business (customer in the vision) receives an ownerless Distributed Renewable Energy system package (e.g. carpenter's workshop) composed of a Distributed Renewable Energy micro-generator and related components and, the related Energy Using Equipment (e.g. circular saw, drill). The ownership of the full-package is retained by the energy supplier or a partnership. This cuts the initial investment costs for the purchase of both the Distributed Renewable Energy micro-generator and the Energy Using Equipment, as well as their life-cycle costs. In fact, many small entrepreneurs/businesses from low and middle-income contexts cannot get a loan from traditional banks. With stable energy access they could increase their business opportunities and working conditions, while empowering local economic growth.

The figure below shows the narration of vision 4: *'Ben is a carpenter in a big city; but he wants to move back to his own village to open a carpentry workshop, but no energy access is available there. If he can have a solar system installed in his carpentry workshop in the village, guaranteeing secure energy access, he can start his business, offering on time delivery, while opening new markets.'*



[Figure 5] Screenshots from the video 'Start-up your Business' paying per period for equipment and energy, by Korapan Vanitkoopalangkul. Text is given by voice narration.

## 2.2 The Scenario design process

The Scenario has been developed within the LeNSes project, to be used by designers and design students within the emerging discipline of *System Design for Sustainable Energy for All (SD4SEA)*. More precisely, it has been elaborated by the Design and system Innovation for Sustainability (DIS) Research Group<sup>43</sup> in the Design Dept. of the Politecnico di Milano (coordinator of the LeNSes project), along a master degree thesis<sup>44</sup>. The research and design path to produce the Scenario have adopted the Method for System Design for Sustainability (MSDS)<sup>45</sup> aimed at support and orient the entire development of system innovations towards sustainability, and organized in five modular phases: Strategic Analysis, Exploring Opportunities, System Concept Design, Design and Engineering the System, Communication.

First phase of the design process to develop the Scenario was the Strategic Analysis (SA), where best practices of Sustainable Product-Service System (S.PSS) applied to Distributed Renewable Energy (DRE) were identified. Next, by abstraction and generalization, six criteria and an articulated set of guidelines were developed. These were all used in brainstorming sessions, during the Exploring Opportunities phase, to generate ideas of Sustainable Product-Service System applied to Distributed Renewable Energy<sup>46</sup>. Resulting ideas were then clustered by identifying characterizing elements. Finally, the polarity diagram of the Scenario was drawn, made up of two intersecting axes (two pairs of polarities) displaying four visions (one vision for each of the four quadrants). These visions together constitute the overall Scenario. A technical review within the DIS research group of Politecnico di Milano allowed final refinement on the Scenario.

## 2.3 The Scenario as a tool

The Scenario, has been developed as a tool for designers to illustrate some of the possible and promising configurations of Sustainable Product-Service System applied to Distributed Renewable Energy<sup>47</sup>. In fact, it presents the four visions through a series of interactive videos<sup>48</sup> accessible through a navigator file.

All visions in the Scenario tool are visually presented as one main video (around 90 seconds), and three sub-videos (around 30 seconds each). The main video shows a narration for each vision, highlighting the main key points of

<sup>43</sup> DIS Research Group, Politecnico di Milano, Design Dept., Head Prof. Carlo Vezzoli, researchers Elisa Bacchetti, Emanuela Delfino, Han Shaohua.

<sup>44</sup> Master Degree thesis, student Korapan Vanitkoopalangkul (2014), supervised by Prof. Carlo Vezzoli; co-supervised by Francesca Piredda.

<sup>45</sup> Method for System Design for Sustainability elaborated within the MEPSS project (EU 5th FP Growth) integrated with the HiCS project (EU 5th FP Growth) and refined within the LeNS project EU Asia-Link funded project, in particular by the DIS unit of Politecnico di Milano (project coordinator).

<sup>46</sup> The SDO Toolikt have been adapted to the new criteria and guidelines and the idea boards of the tools have been used. The tool has been developed by Carlo Vezzoli and Ursula Tischner within the MEPSS EU 5th FP, Growth project.

<sup>47</sup> The Scenario is available online in the LeNSes project platform ([www.lenses.polimi.it](http://www.lenses.polimi.it)), for free use and download in an open source and copyleft logic, under Creative Commons license.

<sup>48</sup> For the purpose of video making, a collaboration with the Imagis Lab (<http://imagislab.it/>) of the Politecnico di Milano was activated.

the vision (e.g. stakeholder relations, system ownership, etc.). Sub-video 1 shows the offer and the related payment method; sub-video 2 shows the stakeholders involved and their interactions; sub-video 3 shows the sustainability dimensions (environmental, socio-ethical, economic) of the system offer<sup>49</sup>. To facilitate the interaction with the Scenario as a tool, the Scenario is presented as a power-point presentation, where each main video and sub-video can be watched. A central button is placed in the middle of the screen to run the whole videos as one (see [figure 1]).

### 3. The Scenario: on field experiences

The Scenario has been experienced, together with other tools, between 2015-2016 as design tool within pilot and curricular courses for design students (Nairobi - May 2015, Milan - March-May 2016) as well as within lifelong learning courses for companies (Gaborone – May 2016, Kampala – July 2016) of the LeNSes project, where was aimed at inspire the courses participants, towards new visions of Sustainable Energy for All solutions.

#### 3.1 The Scenario within the courses design process

The Scenario and the other tools, have been integrated within the Method for System Design for Sustainability (MSDS), adopted during the courses and adjusted according to the specific needs of design students/companies and to diverse design contexts and conditions.

The overall objective of using the Scenario during courses, was to illustrate the promising visions of S.PSS applied to DRE in low and middle-income contexts, in order to present and generalize their main characteristics, and consequently apply them during the design of new concepts. The Scenario has been shown during each course in the early stages of the design process (Exploring opportunities phase of the MSDS method) giving design inputs to design students and companies. Particularly, design students during pilot and curricular courses, they were asked to design sustainable energy solutions in relation to eating or washing systems in specific African contexts; representatives from companies during lifelong learning courses, were focused on design sustainable business offers to improve sustainability and value of their current businesses. Below a short introduction on the courses, where the Sustainable Energy for All has been experienced, is given.

The “*System Design for Sustainable Energy for All*” pilot course, was held by the University of Nairobi in collaboration with the DIS Research Group by Politecnico di Milano from 4 to 15 of May 2015, involving 20 African students of design and engineering. Aim of the course, was to design Sustainable Cooking solutions for local communities in Kenya.

The “*System Design for Sustainability*” curricular course, held by Politecnico di Milano from March to June 2016 (professor Carlo Vezzoli), has involved 60 international students from the design field. Developed concepts were Sustainable Solutions for cooking system for South Africa, Botswana and Uganda; and washing systems for Kenya.

The first “*Designing Sustainable Product-Service System (S.PSS) Offer Models for Distributed Renewable Energy (DRE) systems*” lifelong learning course for companies was held by the University of Botswana in collaboration with the DIS Research Group by Politecnico di Milano from 2 to 6 of May 2016, involving six energy companies and one research center from Botswana. Companies, organized in groups have formulated two concepts to move their actual business towards more Sustainable solutions, based on the promising model of Sustainable Product-Service System applied to Distributed Renewable Energies.

The second “*Designing Sustainable Product-Service System (S.PSS) Offer Models for Distributed Renewable Energy (DRE) systems*” lifelong learning course for companies was held by the Makerere University (Uganda) as a collaboration between the Centre for Research in Energy and Energy Conservation (CREEC) of the University and the DIS Research Group by Politecnico di Milano from 19 to 22 of July 2016, involving eight energy companies from Uganda. Participants were asked to innovate their existing businesses, through the design of Sustainable Product-Service System applied to Distributed Renewable Energy solutions.

<sup>49</sup> Sustainability considerations are formulated through the SDO Toolkit - sustainability dimensions and the related criteria. Environmental dimension: system life optimization/transportation-distribution reduction/resources reduction/waste minimization-valorization/conservation/biocompatibility/toxicity reduction; socio-ethical sustainability: improving employment-working conditions/improving equity and justice in relation with stakeholders/enabling responsible-sustainable consumption/favoring-integrating the weak and the marginalized/improving social cohesion/empower-valorize local resources; economic sustainability: market position and competitiveness/profitability-added value for companies/added value for customers/long term business development-risk/partnership-cooperation/macro-economic effect.

An evaluation of the Sustainable Energy for All Scenario as a tool has been collected by the participants from all courses, to be used for design, technical and conceptual improvements by the DIS Research Group. Learning resources from the courses are available in open source and copy-left at [www.lenses.polimi.it](http://www.lenses.polimi.it) (section courses); the tools used, together with others related to System Design for Sustainability, are available in open source and copy-left from the same website (section tools).

#### 4. Lesson learned

The illustrated Scenario, experienced in courses for design students and companies, has been considered and evaluated by participants and staff as a promising way to illustrate and enlarge new visions on the promising model of Sustainable Products Service System (S.PSS) applied to Distributed Renewable Energy (DRE). At the same time, this calls for a new role, knowledge base and know-how for a new generation of designers and design educators, which is recognizable in the System Design for Sustainable Energy for All (SD4SEA) emerging discipline. In fact, the SD4SEA as approach, seems to be promising to facilitate the design of the transition path leading towards real implementation and diffusion of sustainable energy solutions.

However, the current Scenario, is dedicated to Distributed Renewable Energies, as specific typology of Distributed Economy. The Politecnico di Milano (coordinator), together with 13 partners and 22 associates, have been awarded in 2015 of a new project titled: LeNSin – the international Learning Network on Sustainability (EU funded Erasmus+ programme 2015-2018), aimed to improve the internationalisation, intercultural cross-fertilisation and accessibility of higher education on Design for Sustainability (DfS); and with a focus on Sustainable Product-Service Systems (S.PSS) and Distributed Economies (DE) – considering both as promising models to couple environmental protection with social equity, cohesion and economic prosperity – applied in different contexts around the world. Within this new project, and on the base of the Scenario experience, a Scenario related to the promising models of Sustainable Product-Service System and Distributed Economies, is currently under development.

#### 5. Acknowledgment

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