VISUALISING STAKEHOLDER CONFIGURATIONS IN DESIGNING SUSTAINABLE PRODUCT-SERVICE SYSTEMS (S.PSS) APPLIED TO DISTRIBUTED ECONOMIES (DE): A NEW STAKEHOLDER SYSTEM MAP FOR S.PSS&DE

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ABSTRACT

In the transition towards to a sustainable society for all, an emerging design discipline: System Design for Sustainability for All (SD4SA) has been proposed by the LeNSin project-the International Learning Network of networks on Sustainability (Erasmus+ programme, EU funded-2015-2019), where focusing on developing the new knowledge-base and know-how for designing Sustainable Product-Service System (S.PSS) applied to Distributed Economies (DE). This paper describes a (co)-design and visualisation tool within the SD4SA discipline: "Stakeholder System Map for S.PSS&DE", deeply modified from the first system map tool (Jégou et al., 2002) and adapted to the specific context of designing S.PSS solutions to DE models, that can enable an effective integration of seven DE types and five DE configurations. It has been evaluated within a set of pilot courses of LeNSin project, but also with experts to lead to the final tool that is freely available and open access on the LeNS website.

Key Words: Sustainable Product-Service Systems (S.PSS), Distributed Economies (DE), system design tool, stakeholder system map

1. INTRODUCTION

The International Learning Network of networks on Sustainability – LeNSin EU-supported (ERASMUS+, 2015-2019) project involving 36 universities from Europe, Asia, Africa, South America and Central America, is a multi-polar network of Higher Education Institutions aiming at curricula development on System Design for Sustainability for All (SD4SA), i.e. the design of systems of products and services combine environmental protection with social equity, cohesion and economic prosperity – applied in different contexts around the world, based on the promising models of Sustainable Product-Service System (S.PSS) and Distributed Economies (DE), addressing the promotion of a new generation of designers (and design educators) capable to effectively contribute to the transition towards a sustainable society for all.

Based on the first stage research results of S.PSS applied to DE, a promising approach to diffuse sustainability in low/middle-income(all) contexts, the SD4SA emerging discipline have been developed as the potential source of new knowledge and know-how for designers, design educators and students dealing with Designing S.PSS applied to DE. In fact, a new and key role for designer in a SD4SA approach, is to design "appropriate stakeholder configuration", while addressing S.PSS applied to DE. This discipline has been defined as "design of S.PSS applied to DE, i.e. the design of Systems of Products and Services applied to Distributed Economies artefacts that are together able to fulfil a particular customer demand (deliver a "unit of satisfaction"), based on the design of innovative interactions among locally-based stakeholders, where the ownership of the product/s and/or the life cycle services costs remain by the provider/s, so that economic interests of the provider/s continuously seek both environmentally and socio-ethically beneficial new solutions, i.e. solutions accessible to all" (LeNSin project, 2019).

Along the LeNSin project, with in the SD4SA discipline, a series of tools have been designed and experienced. Those are now available for free on the LeNSin project website www.lens-international.org (tool section). In this paper, the new tool "Stakeholder System Map for S.PSS&DE" is described.

2. METHODOLOGY

1). Development. Drawing from literature review on S.PSS visualization tools and from previous LeNSin project research activities, the particular elements and a set of rules to visualise S.PSS&DE were developed.

2). Evaluation. The new Stakeholder System Map for S.PSS&DE and other tools, have been experienced and integrated within the Method for System Design for Sustainability (MSDS)1, adopted during the pilot courses (India-February 20182, Mexico-May 20183, Brazil-March 20184) of the LeNSin project and tested in the curricular course held by Politecnico di Milano from March to June 2018 (professor Carlo Vezzoli), both aiming at inspiring the courses participants, towards new sustainable opportunity for all through the S.PSS applied to DE. Participants developed new design concepts of S.PSS applied to DE focus on different design topics in different courses, once the strategic analysis and opportunities exploring developed, they applied the new Stakeholder System Map to visualise and detail their concepts (Halen, Vezzoli, & Wimmer, 2005; Vezzoli, 2010; Ceschin, et al 2014). Then they were asked to present their solutions to all at the end of the course and feedbacks about the tools were collected through interviewing and questionnaires.

3). Considerations for improvements. The evaluating activities led to adjust the tool according to the specific needs of participants and diverse design contexts and conditions to improve the applications.

3. DEVELOPMENT OF THE NEW STAKEHOLDER SYSTEM MAP FOR S.PSS&DE

The stakeholder system map, originally developed by Francois Jégou in the HiCS research project Highly Customerised Solutions, Solution-oriented design, production and delivery systems (European Research, GROWTH Programme/European 5th Framework), is a tool to represent graphically the Product-Service System structure and indicate the stakeholders involved and their interactions. (Jégou et al.,2004, Figure 1). This tool can be integrated in the MSDS designing process of strategic analysis, system concept design, and system detailed design phase (Vezzoli 2010, Vezzoli et al., 2014). Due to the codified visualisation, the stakeholder system map can be also used for communicating the designed solution (Vezzoli et al., 2015). Based on the research achievements of LeNSes project5, new advancements on the map tool has been developed and evaluated focused on Distributed Renewable Energy(DRE) and S.PSS (Emili et al.,2016; Emili, 2017). Meanwhile the design tools focus on the Distributed

[1] Method for System Design for Sustainability (MSDS): A modular method for system design for sustainability has been elaborated within the MEPSS EU project, integrated with outcomes from the HiCS EU project and refined within the LeNS EU project.

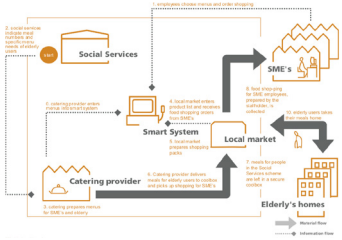
[2] India-February 2018: The "Sustainable Product Service Systems and Distributed Economy "2nd pilot course was held by Indian Institute of Technology Guwahati from 11th to 24th of February 2018. Aim of the course was to disseminate concepts and overall knowledge on Design for Sustainability, particularly the method and tools for Sustainable Product Service System Design applied to Distributed Economies.

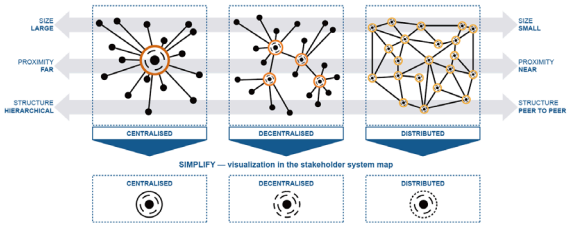
[3] Mexico-May 2018: The "Design for Sustainability" pilot course was held by Universidad del Valle de Mexico from 7th to 18th of May 2018 in campus Lomas Verdes. Designing solutions to the challenges faced by students in paying fees to the university, based on the promising model of Sustainable Product-Service System Design applied to Distributed Economies.

[4] Brazil-March 2018: The "Sustainable Product Service Systems and Distributed Economy"2nd Brazilian pilot course was held by Federal University of Parana from 12th to 23th of March 2018 in Curitiba, involving four design teams from Brazil. Participants were asked to develop concepts focused on the rational use of water within low income households, oriented towards a distributed economy, through the method of Sustainable Product-Service System Design.

[5] LeNSes project: The Learning Network on Sustainable energy systems – LeNSes EU funded Edulink II project 2013- 2016, www.lenses.polimi.it

Manufacturing (DM) and S.PSS have been developed (Petrulaityte et al., 2017, 2018). However, in relation to DE models, S.PSS tools need to extent to the all types of DE that can be used in different scenarios (LeNSin Research Hypothesis II, 2017). As a versatile tool, the system map should be revised and adapted accordingly in order to best describe the complexity of S.PSS applied to all types of DE models, can be used by designers and design students efficiently within the SD4SA discipline, i.e. developing a new Stakeholder System Map for S.PSS&DE.





[Figure 1] Food Delivery Solutions system map of La Fiambrera [Figure 2] Simplify the centralised, decentralised and distributed

3.1. Key elements of SPSS&DE offer models

The first step was to identify and define the key elements to describe the S.PSS&DE models:

- type of distributed economies: it refers to which field of DE involved in the process of designing S.PSS solution, and/or what kind of resources used/shared to deliver the services or products in the system.
- the structure of the system: it refers to the configurations of the DE system, depending on the interaction among the stakeholders of the system as well as from contextual conditions.

3.1.1 Types of Distributed Economies

Distributed Economies can be illustrated a paradigm shift from centralised large production unit and distribution system to small scale locally-based production units empowering end-user control on essential activities (Johansson et al., 2005; Dool et al., 2009) and eventually peer-to-peer network-structured to optimise production and consumption by sharing resources and/or goods and/or information/knowledge (Vezzoli, et, al., 2018). To indicate obviously the characteristics of production units in designing S.PSS solutions applied to DE models, we extract the size proximity (to users), structure features from the respective communication and network attribute of Centralised Decentralised and Distributed (Baran, P., 1964), and simplify them into three independent icons (Figure 2) that can be used directly in the new system map.

Moreover, according to the types of resources shared by production units, DE have been classified in two groups: the hardware/natural resources-based including Distributed energy Generation (DG), Distributed production of Food (DF), Distributed Water management (DW), Distributed Manufacturing (DM), and the knowledge/information-based including Distributed Software development (DS), Distributed Knowledge generation (DK), Distributed Design (DD), totally seven types within the LeNSin 2018. As is shown in the Figure 3, we can use the specific DE types icons combine the economic structure to develop and visualise more in-depth and detailed concepts of S.PSS&DE (more in section 3.3).

3.1.2 Configurations of Distributed Economies

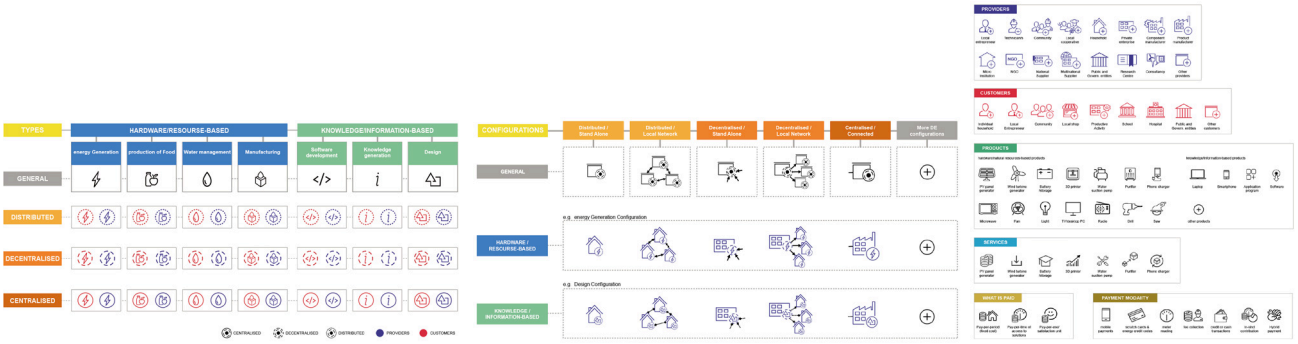
Concerning the structure of the system, five main configurations for describing the S.PSS&DE offer model have been proposed and defined within LeNSin project, and visualised as a set of universal configurations in Figure 4.

1.Distributed Stand Alone. It refers (very) small-scale production units of goods (physical and/or knowledge-based ones) located by the end-users (that become the producers, i.e. prosumer) and can be suggested from household use to small business. Strength of such configurations include easy installation, low investment cost, little maintenance, high degree of flexibility and scalability (Rolland, 2011). 2.Distributed Local Network. Sharing various forms of resources and/or goods (physical and/or knowledge-based ones) among distributed production units at local level. 3.Decentralised Stand Alone. It refers to small-scale production units that deliver their goods (physical and/or knowledge-based ones) at or near the point of production, whether individuals, entrepreneurs or other organisations/institutions. Maintenance and operations are still relatively easy to manage (Rolland, 2011). 4.Decentralised Local Network. Sharing various forms of resources and/or goods (physical and/or knowledge-based ones) among distributed and/or decentralised production units at local level. 5.Centralised Connected. It refers to large-scale production units that control all essential activities and deliver their goods (physical and/or knowledge-based) via great distribution networks, to very many (often) far away customers, whether individuals, entrepreneurs or other organisations/institutions.

3.2. Common elements of SPSS&DE offer models

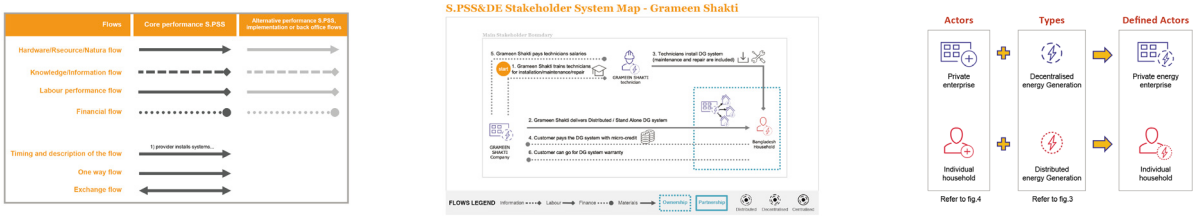
Based on the previous research work that identified elements of the system map (HiCS, LeNSes, LeNSin), the development and adaptation of these common elements to describe S.PSS applied to DE has been described below: Actors contain system solutions providers and target customers, including fifteen provider roles (private enterprise, product manufacturer, et al.) and eight customer roles that have been used in the system map frequently. The category of the products has been enriched and extend to the seven DE types (3D printer, water suction pump, purifier, microwave, laptop, application program, software, et al.). In the whole product life-cycle, services provided to the customers including financing, training, installation, maintenance, use optimization, repair, upgrade, and end-of-

life services. And what is paid by customers for what they gain in the system has been divided into pay-per-period (fixed cost), pay-per-time of access to solutions and pay-per-use/satisfaction unit according to the win-win potential model of S.PSS (Vezzoli et al., 2018), through the various modes of payment (mobile payments, scratch cards & energy credit codes, credit or cash transactions, et al.). These elements of actors, products, services, what is paid and payment modality all have been symbolised with an icon defined by the slogan in the Figure 5.



[Figure 3] DE types diagram [Figure 4] The DE configurations [Figure 5] Icons of S.PSS&DE offers

To clarify the transaction between actors in the system, it has four main types flows: the full, thick arrow indicates material flows (hardware, resource, natura etc.), the fine, square-dotted arrow indicates knowledge/information flows, the full, thick arrow with a diamond at its tip indicates labour performance flows, the fine, round-dotted arrow indicates financial flows. Usually using the dark grey colour to represent the core performance of the main stakeholders, the alternative performance, implementation or back office flows with light grey (Figure 6).



[Figure6] The flows legend [Figure 7] The Example of Grameen Shakti [Figure 8] The way to define the actors

3.3. Visualisation and Communication with the new stakeholder system map for S.PSS&DE

The new stakeholder system map for S.PSS&DE can represent S.PSS solutions in a particular DE satisfaction-system, and simply the understanding of interactions among the socio-economic actors (both primary and secondary stakeholders), in terms of flows of hardware, resource/natura, service, knowledge/information, Labour, and finance. With the standard graphical language, it can be shared and communicated in the whole design team or by different actors involved to support and facilitate the conversation and development of the design concepts.

From the example of Grameen Shakti (Figure 7) the company offers solar home systems with a service package to the low-income households living in rural isolated areas of Bangladesh by the S.PSS&DE offer models, it worth to highlighting the regularised visualisation rules of how to use the tool to represent S.PSS applied to DE:Actors. The system solution provider/s, which can include a single actor or a partnership of actors with a solid blue square around, is represented on the left-hand side of the map and characterised by dark violet colour with descriptive text, while the customer is always placed on the right-hand and illustrated by magenta colour. Ownership described with dashed square by the blue colour. Besides, it is essential to indicate the scale (centralised, decentralised, distributed) of actors and what type resources they provide/gain in the system for visualising S.PSS&DE(Figure.8).

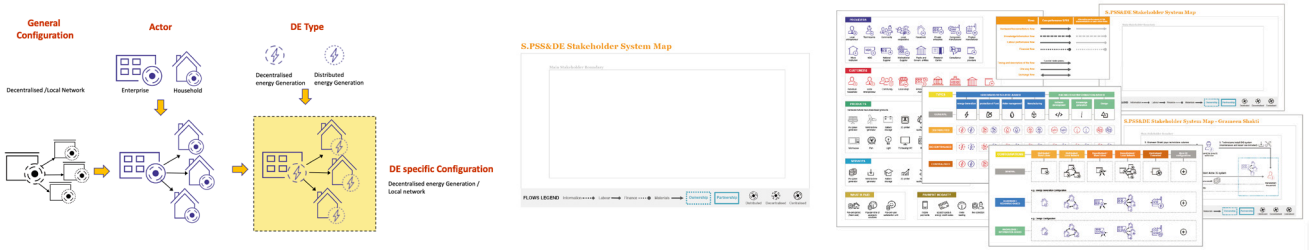
Flows. The interaction flows are made up of arrows and descriptions including the text and corresponding icons, ordered with progression numbers and descriptions to facilitate the reading of the map. By convention, flows of material are placed in the top-middle part of the map to show the transactions between providers and customers, the payments are described in the bottom of the map, showing what the customers pay for and what modalities are used.

DE configuration. The DE configuration is made up of actors involved in the interactions of offer model and the arrows to indicate the transaction and resources type (physical and/or knowledge-based). The way to present the DE configuration has been shown in the Figure 9.

System boundary. From the template of the tool (Figure 10), the system boundary is the constraint of the worksheet, while the offer boundary i.e. “Main Stakeholder Boundary” is defined with a grey box on the central of the map to show the core actors performing the system. Secondary stakeholders which are involved in supporting the S.PSS solution but they are not directly involved in providing the offer to end-users can be placed outside the area.

The new Stakeholder System Map for S.PSS&DE tool (Figure 11) is available for a free download at www.lens-international.org. It can be used in the slideshow software (e.g. Microsoft PowerPoint), which allows users to modify and customise the elements of the systems. The time required to generate a stakeholder system map for S.PSS&DE is approximately 30 min. For more complex systems additional time may be required.

4. TESTING ACTIVITIES



[Figure 9] How to represent a DE specific configuration [Figure 10] The template [Figure 11] The new stakeholder System Map tool

The new Stakeholder System Map for S.PSS&DE has been empirically tested during the course of "System Design for Sustainability" of Politecnico di Milano in May 2018. The 40 international students from the design field were worked in 6 groups and focused on the topic of eating systems for Bovisa (campus of Politecnico di Milano), driven by the design methodology of S.PSS applied to DE. They were asked to visualise their concept models and further detail the stakeholders' interactions through the new Stakeholder System Map tool. After that, the testing activities involved a discussion regarding potential applications of the tool. Feedbacks were collected through questionnaires and the results are discussed as follows (Table 1). The aim of the testing activities was to assess the comprehension and usability, the usefulness and impact of the new Stakeholder System Map for S.PSS&DE as a strategic design tool.

Tool: S.PSS&DE Stakeholder System Map	No answer	Not at all satisfied	Slightly satisfied	Moderately satisfied	Very satisfied	Completely satisfied
1.Comprehension& Usability of the tool	0%	0%	10%	30%	60%	0%
1.Usefulness& Impact of the tool	0%	0%	0%	10%	50%	40%

[Table 1] The participant's evaluation on new Stakeholder System Map for S.PSS&DE

The students evaluated on new Stakeholder System Map for S.PSS&DE quite positively. 60% are very satisfied with the usage of the new system map, 90% participants can have a well understanding of the tool. The feedback of the comprehension and usability highlighted that the classification icons, flows and actors can help them design their concepts and clarify the interactions between different roles. As general comment, the specific tools for defining DE types and DE configurations are necessary that they can design and visualise S.PSS&DE models in a simple and effective way. Other feedback referred to the usage of the tool indicate that they have to think more how to use the tool correctly and the power point is not the best program for using this tool. For the satisfaction of the usefulness and impact, showing more positive results (40% completely satisfied and 50% very satisfied), almost all of feedback was related to: the willingness and interests to use the tool to visualise the concept in the future. In addition-the comments explain that this tool as a standardised graphic language can reduce the difficulty of communication among team members in the design process. While some interesting points should be considered during the testing activities and field experience of the pilot course (details refer to the footnote 2,3,4): the customization rules of icons and configurations i.e. how to ensure the users of the tool to develop the customised icons and configurations efficiently and simply; improvements on the ways of presenting the roles and interactions e.g. the usage of less slogan text to achieve more higher readability; the development of the dedicated program for the system map tool to reach higher operability; the types involved in the DE will be further expanded and more icons (actors, products, services, et al.) and configurations should be studied and refined.

5. CONCLUSIONS AND FURTHER RESEARCH ACTIVITIES

This research aims at addressing the progression of the stakeholder system map as a representational tool can be adapted and experienced as the S.PSS&DE develop. The new Stakeholder System Map for S.PSS&DE encompasses the seven major DE types that can describe most concepts of DE models with the standardised icons, flows, configurations and specific rules in the S.PSS solution. The testing activities demonstrated that the new Stakeholder System Map for S.PSS&DE can be used to design and detail S.PSS solutions applied to DE effectively and easily. The feedback collected during the curricular and pilot course helped to clarify the needs for improvements of the tool and further testing activities with a wider range of design practitioners.

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