AN AFRICAN-EUROPEAN NETWORK OF DESIGN UNIVERSITIES FOSTERING THE GOAL OF SUSTAINABLE ENERGY FOR ALL

An innovative teaching approach based on the combination of Distributed Renewable Energy and design for Sustainable Product-Service Systems

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Abstract

This paper presents the intermediate results of the Learning Network on Sustainable Energy Systems (LeNSes) an African-European multi-polar network for curriculum development on Design for Sustainability (DfS) focused on Distributed Renewable Energy (DRE) and Sustainable Product-Service Systems (S.PSS).

The paper discusses the convergence between the S.PSS and DRE models as promising approaches to provide sustainable energy solutions for all by increasing its access and improving efficiency in use. Currently, the project partners are collaboratively developing new curricula focused on these combined approaches. The paper examines the S.PSS and DRE models and how they can be used to develop and implement sustainable energy solutions for all within the African context. The research hypothesis is that S.PSS could be applied to DRE to offer a range of benefits such as: economic, environmental and socio-ethical. The paper describes some of the project activities that includes: development of a new modular and adaptable package of learning resources focused on DRE and S.PSS for the design discipline; implementation of pilot courses at African Higher Educational Institutions (HEIs) targeted at undergraduate and graduate students, practitioners and companies; and development of an open web platform for distributed production and transfer of knowledge and know-how in this area.

The innovation of the project described in the paper is twofold, firstly by developing unique curricula based on design for sustainability focused on S.PSS and DRE applied to the African contexts, and secondly by delivering it through an open platform for free and in copy-left. This will equip design students in African universities with a broad knowledge base, as well as effective methods and tools with which to play an active role in the development and diffusion of sustainable energy systems.

Keywords: Open learning web platform, Design for Sustainability, System Design for Sustainable Energy for All, Design Curricula Development, African Higher Education Institutions

INTRODUCTION

This paper presents the intermediate results of the ***Learning Network on Sustainable Energy Systems (LeNSes)*** project – an African-European multi-polar network for curricula development on *Distributed Renewable Energy (DRE)* and *Sustainable Product-Service System (S.PSS).* The project is funded by the

European Union (EU) 2013-2016, Edulink Programme and involves four African and three European universities offering design-specific programmes of study.

Energy is a fundamental imperative to the quest for sustainable development. It has a direct influence on the social, environmental and economic aspects of development. Arguably, energy is an all pervasive sector and the catalyst for a myriad of national and regional developmental goals. Consequently, none of the Millennium Development Goals (MDGs) can be met without substantial improvements in the quality and quantity of energy services in emerging and low-income countries. To this end, the United Nations optimistically promotes the MDGs as "*the most successful global anti-poverty push in history. Governments, international organizations, and civil society groups around the world have helped to cut in half the world's extreme poverty rate"* (United Nations, 2014). Whereas all eight MDGs require energy security to be actualized, two specific MDGs directly refer:

- MDG 7: *To ensure environmental sustainability*; and
- MDG 8: *To develop global partnership for development* (ibid).

Further, MDG 7 aligns with the stated objective of the LeNSes project of responding to the challenge of providing ***sustainable energy solutions for all***, whilst concomitantly ***increasing the access to energy*** and ***improving its efficiency***. Subsequently, this paper interrogates two interwoven models to demonstrate the efficacy of the LeNSes project: the ***Sustainable Product-Service System (S.PSS)*** and the ***Distributed Renewable Energy system (DRE).***

With respect to MDG 8, a number of high profile international initiatives have evolved to promote and leverage global partnerships to advance the developmental agenda. According to estimates, a significant majority of the population (of more than 70% or 600 million people) living in sub-Sahara Africa do not have access to the electricity grid (USAID, 2014). One such example that relates to the African context is the ambitious public-private partnership known as the *Power Africa* initiative that was launched by President Obama of the USA in Cape Town, South Africa in June 2013 (ibid). The initial rollout of the Power Africa project will include six sub-Saharan countries, namely; Ethiopia, Ghana, Kenya, Liberia, Nigeria and Tanzania to implement "more than 10,000 megawatts (MW) of clean, efficient electricity generation capacity" (ibid). The LeNSes projects specifically aims to aid in capacity building and knowledge exchange with African Higher Education Institutions (HEIs) in Botswana, Kenya, South Africa and Uganda in partnership with European HEIs in Italy, The Netherlands and the United Kingdom.

More recently, the first *United Nations Environment Assembly* was convened in June 2014 in Nairobi, Kenya (United Nations Department of Economic and Social Affairs, 2014). The 163 member states of the United Nations attended this high level event proposed a list of 17 *Sustainable development Goals* (SDGs) to be attained by 2030. Those that have a bearing on the LeNSes project include *inter alia*:

- SDG 7: *Ensure sustainable energy for all*;

- SDG 9: *Promote sustainable infrastructure and industrialization and foster innovation*;
- SDG 12: *Promote sustainable consumption and production patterns*;
- SDG 13: *Tackle climate change and its impacts*; and
- SDG 17: *Strengthen the means of implementation and the global partnership for sustainable development*.

The proposed SDG 7 (of ensuring sustainable energy for all) is of particular relevance to the LeNSes project that is the purview of this paper (ibid).

The research working hypothesis of the LeNSes project is that S.PSS could be effectively applied to DRE, representing a promising opportunity to couple several benefits: economic ones (reduced cost of energy, increased reliability), environmental (efficiency gains, reduced emissions) and socio-ethical ones (democratisation of access to energy, increased participation and independence of local people).
Within this perspective, participating design HEIs will be able to equip design students with a broad knowledge base, as well as effective methods and tools so that a new generation of designers and engineers can play an active role in the development and diffusion of sustainable energy systems in specific in Africa. This is the main goal of the LeNSes project.
The paper is structured as follows. It firstly presents and discusses the two models of S.PSS and DRE, as well as the opportunities derived from the combination thereof. The paper subsequently presents and reflects on the strategy adopted in the LeNSes project to integrate the teaching of S.PSS design applied to DRE in African universities (HEIs) offering design programmes.
Finally the paper discusses the activities implemented so far and the medium- and long-term potential benefits for the project beneficiaries. It is anticipated that the outputs of the LeNSes project will beneficiate capacitation efforts in the pedagogic, didactic, professional and socio-technical domains in their collective efforts to secure sustainable energy for the realization of diverse MDGs and SDGs across the continent.

DISTRIBUTED RENEWABLE ENERGY (DRE) AND SUSTAINABLE PRODUCT-SERVICE SYSTEM (S.PSS) : SHORT INTRODUCTION

1. DRE: description of the model and its potential benefits

Energy is the world's largest industrial sector, but the dominant energy system is far from being the right one to harness energy in a sustainable way to all. A paradigm shift is needed to lead to a new era driven more by democratic and inclusive decentralized/distributed systems based on renewable energies.
Within this perspective several authors (Barbero & Pereno, 2013; Colombo et al., 2013; Sustainable Energy for All 2011; Rifkin, 2002 and 2010; Vezzoli, 2010; Johansson, Kisch & Mirata, 2004; Vezzoli, Ceschin & Diehl, 2015) concur that the transition from centralized and non-renewable fossil fuel resources (oil, coal, etc.) to renewable energy (biomass, solar, biogas etc) plays a key role in the transition towards sustainable development.

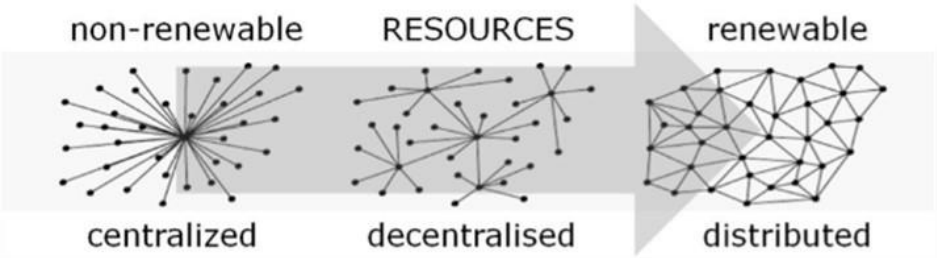

Figure. 1 The paradigm shift from centralized/non-renewable to distributed/renewable energy generation systems.

A Distributed Renewable Energy (DRE) system could be defined as: *a small-scale generation plant sourced by renewable energy resources (such as sun, wind, water, biomass and geothermal energy), at or near the point of use, where the user is the producer, whether an individual, a small business and/or a local community and if a small-scale generation plant is connected with others (to synergically share the energy surplus), they become a Renewable Local Energy Network; eventually connected with nearby similar networks* (LeNSes project definition).

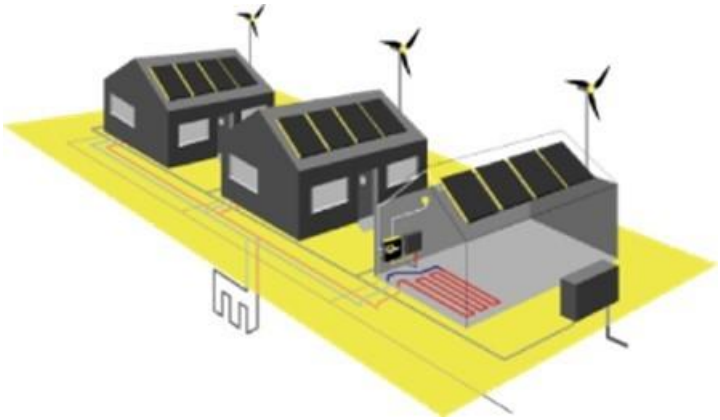

Figure 2. A schematic representation of a (DRE) powered by solar panels and wind systems, sharing energy surplus within a micro-grid (source: www.qurrent.nl).

In fact, DRE can be a promising model, leading to the use of local resources while preserving the environment, creating employment, promoting income generation, capacity building and local empowerment. Further considerations, to reinforce the above assumptions, are presented in relation to the economic, socio-ethical and environmental dimensions of sustainability of Distributed Renewable Energy systems.

As per their nature DREs promote the use of locally-based - distributed and eventually network-structured - renewable resources, such as the sun, wind, water, biomass and geothermal energy, presenting indubitable environmental advantages, due to their reduced greenhouse effect, inexhaustibility and lower environmental costs compared to the various processes of extraction, transformation and distribution of fossil fuels. Moreover, DRE technologies are relatively easy to install and manage by *small-scale economic entities* such as a single individuals and/or local communities, enabling the end-users, to be no longer only a consumer but also producer of the energy in use. Renewable Local Energy Networks, composed by a number of such local micro-plants (whether

purchased or managed), create micro energy-grids, locally based and network structured. Consequently, the expansive usage of distributed generation of renewable resources could lead to an extensive redistribution of power towards single individuals, which is necessary to establish conditions toward a more sustainable development; causing a radical change in important flows of power: no longer from top downward, but from bottom upward.

Finally, DREs are increasingly seen 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 (Colombo et al. 2013). In other terms, the dissemination of DRE in low and middle-income contexts represents a paradigm shift needed in the energy sector at global level (Colombo et al., 2013; Vezzoli, 2013; Vezzoli, Ceschin & Diehl, 2015).

2. S.PSS: description of the model and its potential benefits

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 through a stringent interpretation of environmental and social 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 in 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 refers to *Sustainable Product-Service System (S.PSS)* which can be defined as '(Vezzoli et al, 2014) *"an offer model providing an integrated mix of products and services that are together able to fulfil a particular customer demand (to deliver a "unit of satisfaction"), based on innovative interactions between the stakeholders of the value production system (satisfaction system), where the economic and competitive interest of the providers continuously seeks environmentally and socio-ethically beneficial new solutions"*.

S.PSSs have been studied in industrialized contexts since the end of the 90's, as a paradigm shift from traditional product selling business model able to decouple the creation of value from consumption of materials and energy and thus significantly reduce the life-cycle environmental load of current product systems, as illustrated in Figure 3.

Figure 3. The paradigm shift from a traditional product selling model to Sustainable Product-Service System.

3. Combining DRE with S.PSS

In the previous sections, we presented two promising sustainability models: Distributed Renewable Energy (DRE) and Sustainable Product-Service System (S.PSS). In this section, the authors propose to use both *S.PSS* and *DRE* to reach a challenging sustainable model, as the research hypothesis of the on-going LeNSes project outlines. The DRE and S.PSS models are both win-win strategies. A proposed new model based on S.PSS applied to DRE, can potentially have a couple of multiple sustainable benefits for users such as: economic (reduced cost of energy, due to increased resiliency and reliability), environmental (efficiency gains, reduced emissions), and socio-ethical (democratization of access to energy, increased participation and independence of local people).

4. System Design for Sustainable Energy for All: a design research hypothesis

Based on the combination of DRE with S.PSS, a new potential role for design emerges. We can call this new design approach *System Design for Sustainable Energy for All:*
"Design a system of products and services for an on-site Distributed Renewable Energy generation to be able to "power" the fulfilment of the customer demand/s ("unit of satisfaction") with accessible cost; an offer model based on an innovative interactions of the stakeholders (of the "satisfaction" production system) where the economic and competitive interest of the providers continuously seek both environmentally and socio-ethically beneficial new solutions that eventually include the offer of a local energy network."

The LeNSes project aims at building a new curricula based on the above reseach hypothesis, and this curricula is being developed and will be delivered through an innovative teaching approach discussed in the following sections.

5. The LeNSes project: process and expected output

Based on the above research hypothesis, the LeNSes process foresees the development of new curricula (to respond to local needs and demands in the economic, social and cultural levels).
The LeNSes approach is based on a free-access, open-source, copy left and modular learning model. In particular, LeNSes aims at developing an open online platform[1] (based on the LeNS project experience, see Vezzoli and Ceschin, 2011), to allow a decentralised and collaborative production and fruition of knowledge, specifically dedicated to topics related to Distributed Renewable Energy and Sustainable Product-Service System design. It can be described as a *modular e-package of teaching materials* (slide shows, texts, audio, video, etc.) that design researchers/educators (as well as students, designers, entrepreneurs and other interested stakeholders) are able to *download* (free of charge), *modify, remix and reuse* (in a copy left logic). Apart from the content, the same LeNSes platform is realised in an open-source and copy left logic, allowing other HEIs to download and reconfigure it in relation to their specific needs, areas of interest and themes.

[1] Based on the LeNS project experience (see Vezzoli & Ceschin, 2011).

The LeNSes process of new curricula and the Open Learning E-Platform (OLEP) development is visualised in Figure 4 and can be described as follows:

a) ***State of the art.*** The first phase involved setting-up the basis of the project. Each partner gathered and shared knowledge from previous didactic and research experiences in the field of locally-based System Design for Sustainable Energy for All, and African partner HEIs shared specific needs and priorities. In this process, the involvement of local companies, associations and NGOs was anticipated. These stakeholders shared their knowledge and experience on the field, as well as their specific needs and priorities. The results of these activities was the base for the next phases:
b) ***Design and implementation of didactic pilot modules.*** This stage involved the development of all the necessary inputs for the implementation of the didactic pilot courses and teaching subsidies. The didactic pilot courses are designed and the necessary teaching subsidies are developed ex-novo (according to expressed needs and demands). The design of the didactic modules was done in collaboration between African partners, European partners and with the support of the local associates (companies, consultancies and organisations operating in the energy sector). In a first round, the pilot modules implementation have been carried out through an exchange modality: each African partner hosting a course, and an observer in another course implemented in another African partner HEI. Each European partner collaborates in the implementation acting as a guest school. In the second round, courses will be integrated in the African partners' curricula (with a long distance support by European partners).
c) ***Design and implementation of lifelong learning pilot modules.*** This stage deals with the development of all the necessary inputs for the implementation of professional training modules for companies, consultancies and organisations. As a pilot case, each African partner (in collaboration with European partners) will develop and deliver professional training to the respective local companies, consultancies and organisations.
d) ***Development of the Open Learning E-Package (OLEP).*** In parallel with the didactic curricular and lifelong learning activities, the OLEP is under design and development process, to be then filled with content, i.e. learning resources such as slide shows, texts, audio, video, etc., and System Design for Sustainable Energy for All tools. Since this is an open package, it is anticipated that the project will continue to be updated even after the end of the project (Figure 5).
e) ***External evaluation.*** The whole process of curricular and lifelong learning activities design and implementation is constantly assessed by an independent external evaluation.
f) ***Dissemination.*** The results of the implementation of both the didactic curricular courses and lifelong learning modules (and its supporting learning resources and tools) will be collected to be used in a number of dissemination activities. The main ones are: an international conference, a workshop with representative from African HEIs, a book on System Design for Sustainable Energy for All, and a set of guidelines to support HEIs in implementing didactic courses and lifelong learning activities. Most importantly, the OLEP represents itself the main dissemination tool: The OLEP is in fact aimed at

facilitating the adoption, adaptation and development of the project results by other HEIs.

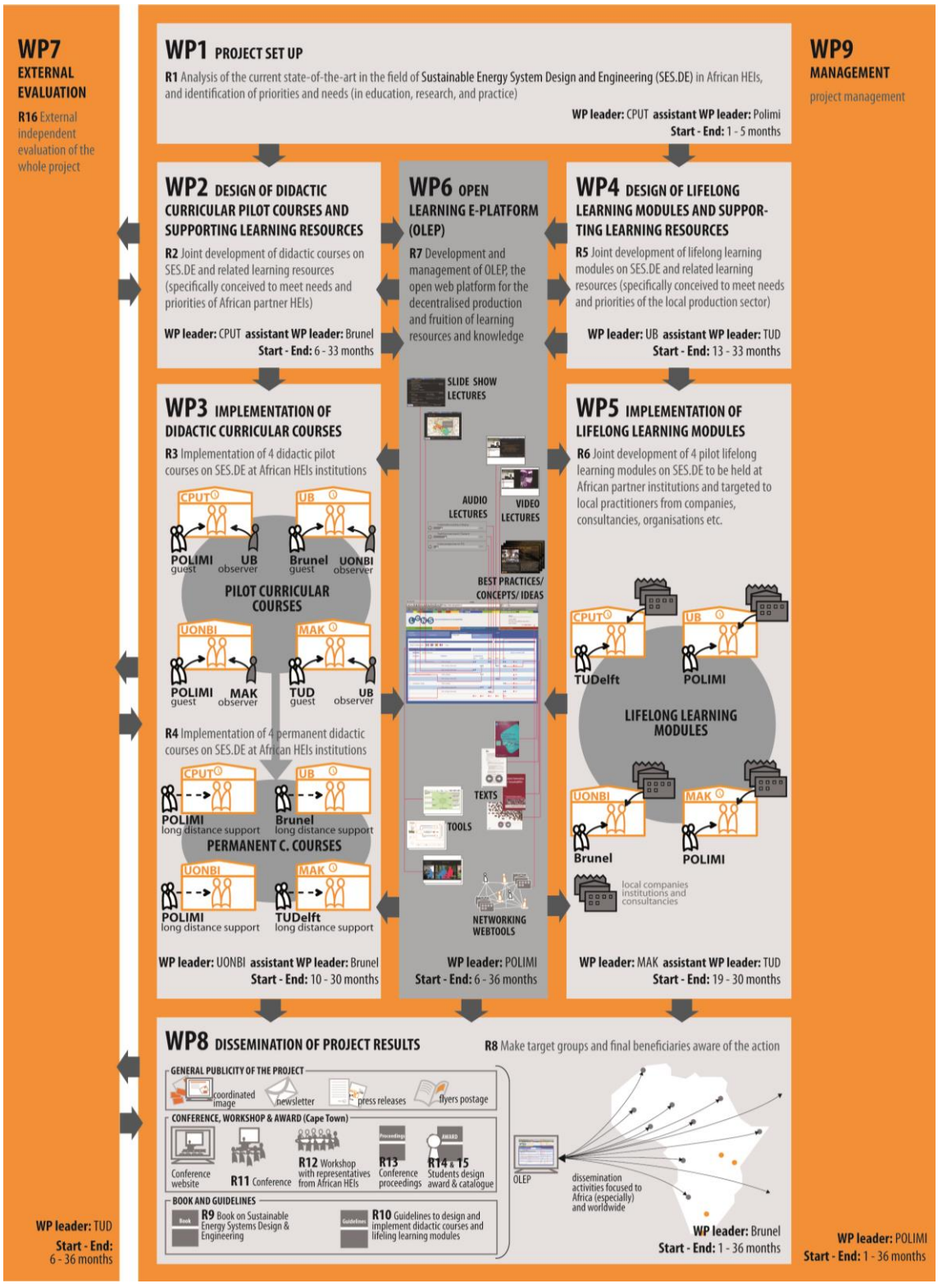

Figure 4. LeNSes Process: main activities and expected results (legend: *WP = Work Package; R= Result).*

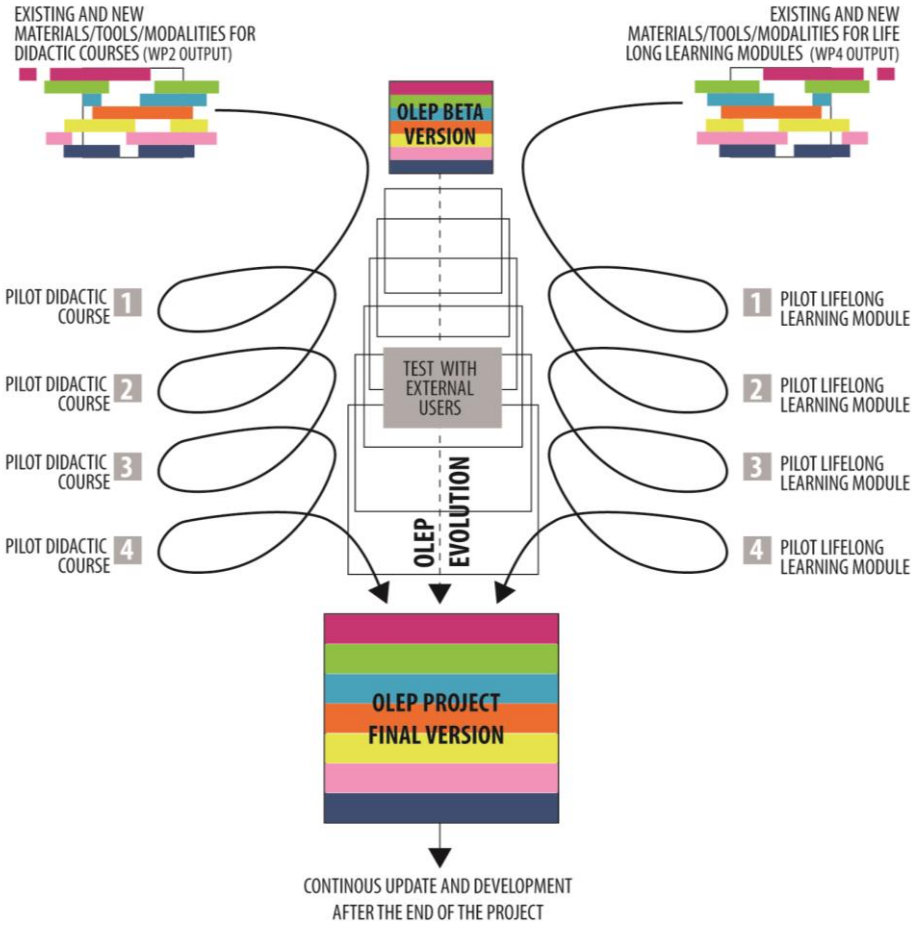

Figure 5. Process of development and evolution of the Open Learning E-Package.

Findings

This section reports on the preliminary findings based on students, teachers and observers evaluation of the pilot courses conducted in three institutions. So far, the project has achieved the following:

Higher Education Institutions:

- Institutional networking: The LeNSes project has stimulated and increased the inter-institutional networking between HEIs in the African and with European HEIs. The project meetings, joint development and implementation of courses and the OLEP has stimulated the institutional networking not only related to educational contents but also to other academic issues such as collaborative research.
- Capacity building: So far staff in the African HEIs have indicated that they have learnt from their European peers as well as by being introduced to new educational approaches such as S.PSS and DRE. Since all the courses were developed by participatory design approaches, there was intensive mutual learning.
- Increased mobility: The implementation of each of the pilot courses has resulted in staff representatives of three different universities attending the courses at different countries. Each of them had a have different role: Host (local African HEI), Guest (European HEI) and an observer (African and

European HEI). In addition the OLEP platform offers opportunities for 'virtual staff mobility' by working with other educational practitioners and/or experts online.

- Connection to societal challenges: The program aims at developing educational materials not only of high quality level, but that is as well efficient, and relevant to needs of the labour markets, skill needs and consistent with the African countries' socio-economic development priorities. Local companies, consultancies, NGO's, public institutions were directly involved in the design and implementation of curricular courses, assuring that all the relevant and specific needs are addressed.

Teachers:

- State-of-the-art: Geographic location is no longer a barrier of having access to state-of-the-art research results and teaching materials. The matter of access to knowledge becomes even more crucial in a research field like Design for Sustainability and Sustainable Energy for All, characterized by being quite recent and therefore not extensively disseminated as well as rapidly developing (Vezzoli & Ceschin, 2011).
- Leap-frog-start: Teaching materials developed by partner institutions developed for similar educational and societal contexts enable teachers to speed up the process of developing new courses which enabled them to spend more time on implementation (teaching) than preparation (course development). Re-use of work of knowledge is encouraged and new ideas can evolve (Baranuik et al. 2004).

Students:

- State-of-the-art: The OLEP platform provided students access to not only the educational materials of their own HEIs but also many others. This enabled them to acquire knowledge from outside, as well as being taught about the latest developments in Design for Sustainability (DfS) applied to S.PSS and DRE.
- Independence: Students are not dependent on the course content provided by their own HEI. If they are motivated and interested in additional lectures and other knowledge resources, they can browse through the OLEP for this.
- Local cases: The locally carried out projects and cases at the three African universities by the students and practitioners was shared in the OLEP. This enabled students to get insights and inspiration of (real life) projects of other student teams which are localised and contextualised to the African setting.
- Change of scope: Students acquired new knowledge and this changed their thinking from tackling design challenges from a product design approach to a product service system approach. Some students expressed the following:
  "The information I got from the DRE was also useful as it gave me more knowledge on sustainable development".
  "… presentation on practical exercise made me understand better how the two can be combined –S.PSS and DRE".

"I was very happy to learn of S.PSS approach in coming up with ways to solve problems in the local community. PSS and DRE working together was also very interesting".

6. The possibility of replicating the platform

Initially, the LeNSes Africa project starts in two regions of Africa: South (South Africa and Botswana) and the East (Uganda and Kenya). Many of the problems and challenges addressed are also relevant to other regions of the African continent. During the project the possibility will be explored to extend the network in two directions: 1) locally by informing, attracting, and inviting universities in the four base countries to join and actively participate, 2) to reach out to West Africa (i.e. Ghana and Nigeria) and North Africa (i.e. Morocco, Algeria and Tunesia). It is expected that African LeNSes program will attract other than the initial stakeholders as well and thus be replicated to wider audience such as for example vocational training institutions.

CONCLUSIONS

There are two key elements peculiar and relevant in the LeNSes project.
The first one is to promote the development of a new knowledge-base and know-how for design combining S.PSS and DRE, i.e. setting the base for a new role as system design for sustainable energy for all.
Secondly, being aware of both the urgent changes required by sustainable development, the potential role of design (and design thinking) in promoting system innovation in the way users produce, consume and interact, as well as the opportunities offered by the ever more interconnected society, the LeNSes network is in fact drawing an agenda for the design community. Coherently with a previous successful experience of LeNS, the Learning Network on Sustainability project[2], LeNSes proposes to make acquired knowledge to be freely and easily accessible in a copy left and open source modality (while safeguarding authorship and scientific recognised publication activity), so forth enabling others in the design community worldwide to acquire them free of charge, with the possibility to replicate, modify, remix and reuse. For the researchers, this knowledge includes acquired research knowledge base (e.g. papers, books, etc.) and know-how (e.g. methods and tools); for educators, this knowledge includes educational resources (slideshows, texts, video of lecture, educational support tools, etc.); for the designers and design thinkers, this knowledge includes the design for sustainability concept proposal of products, services, systems and scenarios, as well as a design know-how. Finally the LeNSes vision is to propose the adoption and diffusion of a new ethos within a worldwide design community: to view design as a unique multi-polar learning community promoting, enabling and activating any possible learning-by-sharing process aiming at effective knowledge osmosis and cross-fertilization in design for sustainability applied to sustainable energy for all in an open and copy left ethos.

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