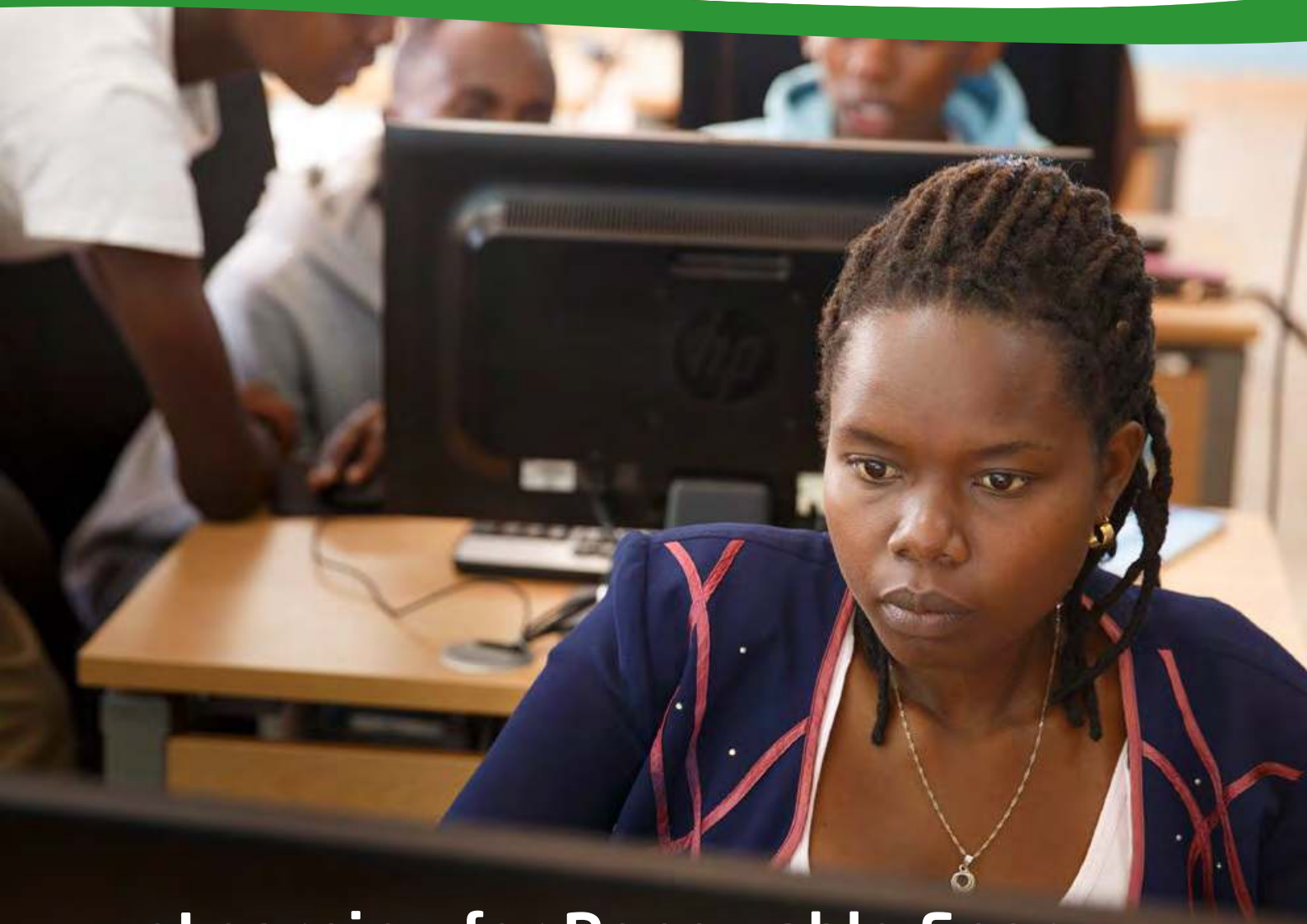
RECP
Africa-EU Renewable Energy Cooperation Programme

Africa-EU Energy Partnership



eLearning for Renewable Energy Higher Education in Africa:
Role, Potential and Outlook

UNITED NATIONS UNIVERSITY

UNU-EHS
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EXECUTIVE SUMMARY

Pointing to the great promise renewable energy holds for affordably mitigating climate change and enhancing energy security, the development of this sector strongly depends on the availability of pertinent and capable human resources. Hence, skills and capabilities are cardinal to the effective development and utilisation of renewable energy technology. To this end, education plays a key role in training individuals in becoming energy professionals in Africa. Engineers, as well as policy-makers need to be trained in order to plan, size, design, develop, operate, and maintain renewable energy installations at all sizes and levels, as well as to develop conducive policy frameworks that promote the use of renewable energy technologies.

The study focuses on the role of educational technology and its potential to enhance and strengthen higher education in the field of renewable energy in Africa. It is targeted at higher education lecturers and managers seeking to use eLearning technologies to enhance their education programmes and courses, managers aiming to implement eLearning supported renewable energy programmes and curricula in their institutions, as well as international organisations involved in support interventions for renewable energy education and training in Africa.

Among others, the study elaborates on the activities and impact from well-established organisations in the sphere of eLearning in Africa with a special focus on renewable energy education. Referring to a previous RECP study on higher education for renewable energy in Africa, this study presents the extended portfolio of face-to-face and eLearning programmes and curricula for renewable energy in Africa and Europe. Furthermore, the study presents a list of Online Courses, Open Educational Resources and MOOCs (Massive Open Online Courses) related to renewable energy higher education.

Yet, the combination of educational technology and renewable energy is less prevalent and is hence offered only by a limited number of African universities or universities that are accessible to Africans. The study then reveals an existing, however not sufficient awareness for the usage of educational technologies in African higher education. It also summarises learning technologies, which could be used to transform a didactical traditional face-to-face curriculum into a blended or eLearning programme or curriculum for renewable energy studies. The reference architecture of a digital learning environment with the integrated components/ tools to support open and distance teaching/ learning is described in the study. The respective components/tools of the architecture are presented and most frequently used solutions in the African context (open source) for their implementation are presented.

Finally, the study provides an outlook and further perspectives on eLearning for renewable energy higher education in Africa. A number of short-term and long-term recommendations that enhance and strengthen eLearning for higher education in the field of renewable energy in Africa are presented.

ABBREVIATIONS AND DEFINITIONS

AEEP	Africa-EU Energy Partnership
ACDE	African Council for Distance Education
AfDB	African Development Bank
AR	Augmented Reality
AU	African Union
AUF	Agence Universitaire de la Francophonie
AVU	African Virtual University
COL	The Commonwealth of Learning
CREST	The Centre for Renewable Energy Systems Technology
EUEI PDF	EU Energy Initiative Partnership Dialogue Facility
GDLN	Global Development Learning Network
ICT	Information and Communication Technologies
MOOC	Massive Open Online Course
NOUN	National University of Nigeria
RE	Renewable Energy
RECP	Africa-EU Renewable Energy Cooperation Programme
REDC	Renewable Energy for Developing Countries
PAUWES	Pan African University Institute of Water and Energy Sciences (incl. climate change)
ODL	Open Distance Learning
OER	Open Educational Resources
OU	Open University
OUT	Open University of Tanzania
Saide	South African Institute for Distance Education
UNISA	University of South Africa
VR	Virtual Reality

TERMINOLOGY[1]

Distance education is a mode of teaching and learning characterised by the separation of teacher and learner in time and/or place for most of the educational transaction, mediated by technology for delivery of learning content. It may involve, for example, face-to-face interaction for learner–teacher and learner–learner interaction; the provision of two-way didactic communication; and economies of scale.

eLearning is an umbrella term that refers to the use of any digital device for teaching and learning, especially for the delivery or accessing of content. Thus, eLearning can take place without any reference to a network or connectivity. The digital device used by the learner to access materials need not be connected to a digital network, either a local area network or the internet (or even to a cell phone network if a tablet is used as a terminal or access device).

Massive Open Online Course (MOOC) is an online course available for large enrolment on the open web, where "open" largely refers to open registration and not necessarily to registration fees or open licensing models of the course.

Open and distance learning (ODL) refers to a system of teaching and learning that is characterised by separation of teacher and learner in time and/or place. It uses multiple media for delivery of instruction; and involves two-way communication and occasional face-to-face meetings for tutorials and learner–learner interaction.

Open educational resources (OER), as defined by the OER Paris Declaration 2012, means any: "teaching, learning and research materials in any medium, digital or otherwise, that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions."

Open University is a type of single-mode distance teaching institution that also offers flexibility in terms of choice of courses, entry requirements, learning media and approaches, and time and place of study. Courses and programmes of an open university may offer different degrees of openness in their provision, based on the nature of the studies and the legal contexts of operation.

Virtual Universities/Cyber Universities are higher education institutions, or networks of higher-education institutions, responsible for designing, developing and offering courses and programmes in a flexible online environment.

Learning Management System (LMS), often called course management system or virtual learning environment, is a web-based software system that assists teachers to manage courses and deliver lessons online. It helps in administration, tracking and reporting of learning processes.

Blended Learning is a teaching and learning approach that demonstrates a blend of different methods, technologies, and resources to improve student learning. Some examples of blended learning are flipped classroom, online interaction followed by face-to-face teaching, and online learning supplemented by face-to-face sessions.

Learning Technologies are used for the enhancement of teaching, learning and assessment. In other words, it is the use of a range of ICT (Information and Communication Technology) for teaching, learning and assessment. Learning technologies can be seen deployed as tools for drill and practice, tutorials, information retrieval systems, simulations, communication, among others.

Online Learning is eLearning with a mandatory involvement of a digital network which a learner needs in order to access at least part of the learning materials and services. Online learning refers to network enabled teaching

1 Definitions are mainly retrieved from the Commonwealth of Learning: http://oasis.col.org/handle/11599/829

and learning that allows the learner to have increased interaction with content, teachers and other learners.

Open Learning refers to policies and practice of openness in entry requirements (with minimal or no restriction on qualifications), choice of courses, or the place of study and time. It is an educational philosophy where learning can happen anywhere, anytime and from any resource. This can be seen as a common practice in face-to-face institutions.

INTRODUCTION: BACKGROUND, CONTEXT AND OBJECTIVE OF THE STUDY

Background

Renewable energy markets in Africa are still in their early stages. In order to enter the job market, for example as renewable energy entrepreneurs or policy-makers, graduates of renewable energy higher education programmes have to be highly flexible and innovative. Therefore, renewable energy programmes need to offer a broad curriculum, straining the universities' human and financial resources. At the same time, distance education has gained significant relevance in Africa, due to decreasing costs of mobile devices, increasing connectivity and a fast developing ICT market. In this light, distance education approaches promise to be low cost, and high impact opportunities for university education. By complementing university programmes with eLearning, human and financial resources can be used more efficiently, while students are provided with modern teaching methods and up-to-date knowledge to successfully enter the job market.

Context of the Study

The study was conducted within the context of the Africa-EU Renewable Energy Cooperation Programme (RECP). The RECP aims at developing renewable energy markets in Africa and is hence catalysing efforts in shaping this market by training the next generation of energy professionals and promoting renewable energy innovation in Africa. One of the principles of the RECP is to complement existing donor initiatives, where possible. With the help of this assessment study, the RECP explores the area of eLearning for renewable energy in African higher education foremost to map the existing initiatives in this field and to identify windows of opportunity. The study has been conducted in cooperation with the United Nations University Institute for Environment and Human Security (UNU-EHS), and authored by Dr Erick Tambo assisted by Lucy Larbi.

Objectives of the Study

The overall goal of this study is to explore the role and potential of eLearning in renewable energy in African higher education and to identify feasible and impactful projects within this field. In general, several programmes and initiatives already exist to foster renewable energy education in the African tertiary sector. However, the idea to provide virtual education in renewable energy higher education in Africa is rather in its infancy, and this is why it is necessary to map the already existing programmes and opportunities as well as make the most of lessons learnt and best practices from other providers of virtual education when engaging in this sector.

Hence, this study showcases the role, potential and avenues of possible cooperation in the field of eLearning for renewable energy in African higher education in order to identify action areas in this respective field.

The assessment:

- provides an overview of eLearning and distance education in Africa, as well as of main actors and initiatives;
- presents renewable energy eLearning programmes in higher education in Africa;
- sketches eLearning programmes and educational technologies related to renewable energy higher education in Europe and lessons learnt;
- discusses potential of renewable energy and distance learning in Africa and submits recommendations designed to induce a way forward.

Target Group

This study is mainly targeted at higher education lecturers and managers seeking to use eLearning technologies to enhance their education programmes and courses, at managers aiming to implement eLearning supported renewable energy programmes and curricula in their institutions. It is also targeted at international organisations involved in support interventions for renewable energy education and training in Africa, and all individuals who seek collaboration in the field of eLearning in renewable energy in Africa or merely seek to expand the knowledge base on this topic.

CHAPTER 1 ELEARNING AND DISTANCE EDUCATION IN AFRICA

Higher education in Africa is facing a critical challenge to meet new demands of the 21st century with the continent's high rates of population growth. The demographic shift will translate into a larger number of students that will seek access to all levels of education, including tertiary education. The use of information and communication technologies can contribute to the expansion of tertiary education as well as accelerate the progress many African countries have already made in education disciplines that are critical to the economic development of Africa.

Virtual education makes it possible for students in any location who have internet and web connections to enrol in online courses and benefit from this alternative way of education. Despite the promises of virtual education, high dropout rates still plague virtual universities, as the online environment requires a high level of self-motivation, discipline and concentration. The best use of online learning is to pair it with some practical instruction and assessment (Mark West, 2015). Despite all intricacies associated with the set-up and advancement of virtual education initiatives in Africa, policy-makers have acknowledged the added value from the usage of educational technologies and increasingly make this a policy priority.

The following section displays a selection of flagship initiatives/programmes that provide educational technology services in Africa, mostly funded by external donors. The selected entities are among the most renowned organisations in eLearning in Africa. The respective activities, impacts, challenges and lessons learnt provide an insight into the functioning and performance of the projects.

1.1 eLearning Flagship Initiatives Relevant for Africa

Commonwealth of Learning[2]

The Commonwealth of Learning (COL) is an intergovernmental organisation created by Commonwealth Heads of Government to encourage the development and sharing of open learning/distance education knowledge, resources and technologies throughout the Commonwealth's 54 member states. COL has evolved into one of the world's leading distance education providers and leads the international development in distance education along with UNESCO. It works with institutional and individual partners to give policy advice and to implement programme activities in consultation with governments, and provides best practice examples that demonstrate how ODL can help education opportunities expand more rapidly.

Among others, COL carries out the following activities related to eLearning:

Synergising: COL focuses and aligns the work of partners on a specific set of educational and learning outcomes, linked to a broad strategy for development.

Consultancy: COL helps governments and other institutions expand the scale, efficiency and quality of learning by using appropriate technologies, particularly those that support open and distance learning.

Alternative form of learning: COL offers other forms of learning: flexible learning approaches for formal and non-formal contexts as well as skills development; a range of different learning strategies and methods to enable the education of girls and women; and a focused approach to the use of radio, text messages, voice mail, television, video, print and newsprint to enable community-based and "village" learning.

Pan African E-Network[3]

The Pan African E-Network is an ICT cooperation platform between India and the African Union to enable access to and sharing of expertise between India and African states in the areas of Tele-Education and Tele-Medicine. It started in February 2009, and aimed at connecting the then 53 African Nations of the African Union through a satellite and fibre optic network that would provide effective communication in two key areas, Tele-Education and Tele-Medicine:

The Tele-Education network consists of five African Regional Leading Universities (University of Kwame Nkrumah in Ghana, Makerere University in Uganda, University of Yaounde 1 in Cameroon, University of Alexandria in Egypt, University of Zomba in Malawi) connected to 53 learning centres on the continent and to seven universities in India. The universities are connected to India via a 2mbps broadband/ VSA. To enhance capacity building, the Indian government has committed to provide free education programmes to 10,000 African students. The educational programmes range from graduate and postgraduate diplomas to certificates, and short term courses in the area of Business Management, Information Technology, Business Administration and Financial Management.

The Tele-Medicine connectivity will enable 12 Super Specialty Hospitals to provide expert services to 53 Remote Hospitals that are equipped with the medical equipment such as Electro-Cardio-Gram (ECG), Ultra Sound, and pathology and X-ray at each location. The network will also provide continuing medical education (CME) services based on the selected

2 Sources: (CoL1, 2015), (CoL2, 2015), (CoL3, 2015) and (Murgatroyd, 2015).

3 Source: (PanAfricanE-Network1, 2016).

Super Specialty disciplines in the medical courses offered by the Indian and AU Regional Super Specialty Hospitals as a certificate and diploma course as per the AU requirement.

Further activities of the network involve support to video conferencing and VoIP services, and support to e-Governance, e-commerce, infotainment, resources mapping, and meteorological services. By the end of 2012, 9916 students from African countries had registered with Indian universities for a variety of postgraduate, undergraduate and certificate courses. The network also provides trainings at the regional centres in Africa for the Telecom, IT and paramedical staff. The network is designed to have 169 terminals (learning centres) that are connected to the hub aiming to strengthen the South-South cooperation.

The Open University – International Development Office[4]

The Open University (OU) is a public distance learning and research institution, and one of the biggest universities in the UK for undergraduate education. Through its International Development Office, the University has also been active in Africa over the past twenty years. Here, the OU helps deliver development programmes in partnership with governments, NGOs, funding institutions and local partners and addresses areas such as frontline health, teacher education and English language teaching. Besides the programmes, the OU provides open educational resources and selected degree courses for African students.

Selected courses of the Open University are available in Africa or via partner universities in Africa. For example, the Open University Business School provides African managers with globally recognised qualifications and expertise. Teacher Education in Sub-Saharan Africa (TESSA) is a consortium of 18 universities, which is working to improve the quality of, and access to, primary school teacher education in Africa. The Health Education and Training (HEAT) project is designed to train and support community health workers across Africa. The OU also acts as consultant to governments that aim to launch their open universities that predominantly teach by distance learning. Currently, the OU is consulting the Ghanaian government in launching the National Open University of Ghana.

OU's wide outreach is reflected in its numbers of beneficiaries: 800,000 teachers have benefitted from OU's TESSA project; more than 21,000 people with disabilities studied with the OU in 2014/15.

African Virtual University[5]

The African Virtual University (AVU) commenced the pilot project phase in 1997. It is the leading Pan African eLearning institution. AVU assists institutions by identifying course demand, providing the technical infrastructure as well as matching students' demands to the institutions' offers. By promoting open distance eLearning, it aims to increase access to affordable tertiary education. Courses are offered in English, French and Portuguese.

The AVU partners with many African universities and institutions to launch new distance learning facilities that offer degrees and diplomas or certificates in ICT, maths and science. AVU offers open educational resources through a portal that currently hosts 219 modules – 73 modules in each of the three languages, including 46 in mathematics and sciences, four in ICT basic skills, 19 teacher education professional courses, and four in integration of ICT in education.

4 Sources: (OpenUniversity1, 2016), (OpenUniversity2, 2016), (OpenUniversity3, 2016), (OpenUniversity4, 2016).

5 Source: (AVU, 2016).

The AVU supports clients in converting existing course material into eLearning format or developing new eLearning material, and consults institutions that want to adopt distance and eLearning. The AVU also acts as a hosting institution by allowing third parties to use the AVU platform to offer programmes and courses.

Since its establishment in 1997, the AVU has trained more than 43,000 students through partner institutions. Also, approximately 1.5 million downloads in the AVU's open education resources took place over a period of five years. The AVU works with more than 50 academic partner institutions in more than 27 countries in Africa and is the largest network of open distance and eLearning in Africa. Further, it has developed over 70 curricular models in English, French and Portuguese.

Formation Ouverte à Distance (Agence Universitaire de la Francophonie)[6]

The Agence Universitaire de la Francophonie (AUF) is an international association comprising francophone universities, grandes écoles, academic networks and scientific research centers all over the world. With a network of 812 members in 104 countries, it is one of theworld's largest higher education and re-search associations. The AUF retains expertise in highereducation and research tailored to francophone countries.

AUF runs an extensive francophone digital campus network on the five continents where it represents a tool for sharing and capitalising experiences, assists in structuring the pedagogic and scientific offer the AUF supplies, and project implementation of university projects. 90 online programmes are offered within the framework of FOAD. FOAD is a collaboration platform involving higher education institutions from the North (mainly France and Canada) and the South (Burkina Faso, Cameroon, Egypt, Senegal, Madagascar, Tunisia, Vietnam, Morocco and Libya).

In the academic year 2016/2017, the AUF offers almost 90 Bachelor and Master degrees as well as certificates entirely remotely. Also Massive and Open Online Courses are offered (MOOC). Study programmes range from engineering and human sciences to medicine and public health, environment and sustainable development, education and formation, law, economics and management. Lastly, the AUF offers scholarships for the programmes.

The AUF offers a series of "training of trainers" workshops for Information Technology and Communication, which are named "Transfer". These training workshops assist in the case of deployment to francophone countries in the South and East where information technologies and communication are to be developed for academia.

The AUF has a network of 36 francophone digital campuses and 39 partners around the world offering different services ranging from access to scientific and technical information infrastructure of distance learning (e.g. videoconferencing), support the production of courses, training of trainers workshops, and the provision of incubators for entrepreneurs. In 2012, 10,131 students were registered to pursue an online degree with the FOAD programme. In total, more than 10,000 students benefitted from the services of the network of the digital francophone campus.

The AfDB eInstitute[7]

The eInstitute is the virtual knowledge and learning environment for capacity building of the African Development Bank (AfDB). The eInstitute knowledge portal is built internally at the AfDB by integrating several open-source and a few

6 Source: Agence Universitaire de la Francophonie (AUF, 2016).

7 Source: Dr Bakri Abdul Karim (RECP Report, 2016).

commercial applications. As such it harvests the Bank's internal knowledge for delivery in distance learning modes including eLearning, mobile learning and blended learning. Further, this institute aims at developing the capacity of AfDB staff and member countries to use ICT to deliver training on the eInstitute platform. Courses on renewable energy are planned for 2016.

The eInstitute harvests the Bank's internal knowledge for delivery in distance learning modes including eLearning, Mobile Learning and Blended Learning. Among others, the portal provides learning and course management systems for learning and training as well as a virtual library and archive management system for the knowledge and virtual resource center. The AfDB is striving to enhance the portal and open it up for learners in Africa as well as others who are interested in development knowledge. The project is envisioned to become the African Knowledge Hub in order to build e-learning capacity throughout the continent.

1.2 National Open Universities

Besides the above-mentioned international initiatives, various African universities provide eLearning courses or eLearning resources in multiple disciplines. The following overview list is non-exhaustive, however the most renowned institutions have been chosen to provide examples of African National Open Universities:

University of South Africa (UNISA): UNISA is not only one of the largest providers of open distance education in Africa but also one of the largest worldwide. UNISA offers internationally accredited Bachelor, Master and doctoral degree programmes in numerous disciplines. The university counts over 300,000 students from more than 130 countries.

National Open University of Nigeria (NOUN): NOUN is Nigeria's largest university and the first provider of open distance education in West Africa. NOUN offers certificates, degrees and postgraduate courses. Currently more than 150,000 students are enrolled in more than 50 programmes, which are nationally accredited. 63 study centres are associated with NOUN.

The Open University of Tanzania (OUT): OUT is the first provider of open distance education in East Africa and operates through 30 regional centres and 70 study centres. OUT offers certificates, diploma, degree and postgraduate courses through five faculties and two institutes. Currently, over 30,000 students are enrolled.

Open University of Zimbabwe: The Open University of Zimbabwe delivers more than 30 programmes. It counts six faculties and 11 regional centres and confers certificates, diplomas, undergraduate degrees, Master's degrees, and PhD degrees. Since 2003, more than 27,000 students have graduated.

1.3 Other Networks and Institutions

eLearning Networks

African Council for Distance Education: The African Council for Distance Education (ACDE) is a continental educational organisation currently comprising 39 African universities and other higher education institutions, which are committed to expanding access to quality education and training through open and distance learning. Participating countries are Botswana, Cameroon, Kenya, Mauritius, Mozambique, Nigeria, Republic of Congo, Ruanda, Somalia, South Africa, Sudan, Swaziland, Tanzania, Zambia and Zimbabwe. In addition, ACDE also hosts a platform on open educational resources in Africa.

Global Development Learning Network (GDLN): Funded by the World Bank, GDLN is a partnership programme of about 120 affiliates in more than 80 countries that helps designing learning programmes in the field of distance learning. The services range from designing and organising formal training courses to multi-country, multi-cultural dialogues and "virtual" conferences, using face-to-face and distance learning approaches. As a global platform for learning and knowledge exchange on development issues, GDLN operates on three levels:

1. Providing the physical infrastructure for learning and knowledge-sharing activities in capital cities and in remote areas.
2. Offering a broad set of advisory and implementation services from needs assessments to the design, delivery, and evaluation of learning activities and products.
3. Providing access to a wealth of know-how and sector expertise.

e/merge Africa: e/merge Africa is a new educational technology network which has been designed for educational technology researchers and practitioners in African higher education. It offers regular online seminars, workshops and short courses. Upon the scrutiny of a proposal, e/merge allows individuals to lead a seminar, workshop or short course on its platform. Also, interested students are screened for eligibility and have to hence undergo a selection procedure.

Think Tanks – Research Institutes

South African Institute for Distance Education (Saide): Saide's task is to contribute to the development of new models of open and distance education practice that accord with and take forward the values, principles, and goals of the evolving education systems in the Southern African region. It has also paid particular attention to the appropriate use of technology in education and most recently established a Kenya-based initiative, OER Africa (Open Educational Resources), to promote the development and sharing of OER on the African continent. Saide acts as an advocate, catalyst, and facilitator to bring about change in existing educational practices.

Research on open educational resources for development (ROER4D), South Africa: The primary objective of the ROER4D programme is to improve educational policy, practice, and research in developing countries by better understanding the use and impact of OER. ROER4D does this by building an empirical knowledge base on the use and impact of OER focusing in post-secondary education, developing the capacity of OER researchers, building a network of OER scholars and communicating research to inform education policy and practice.

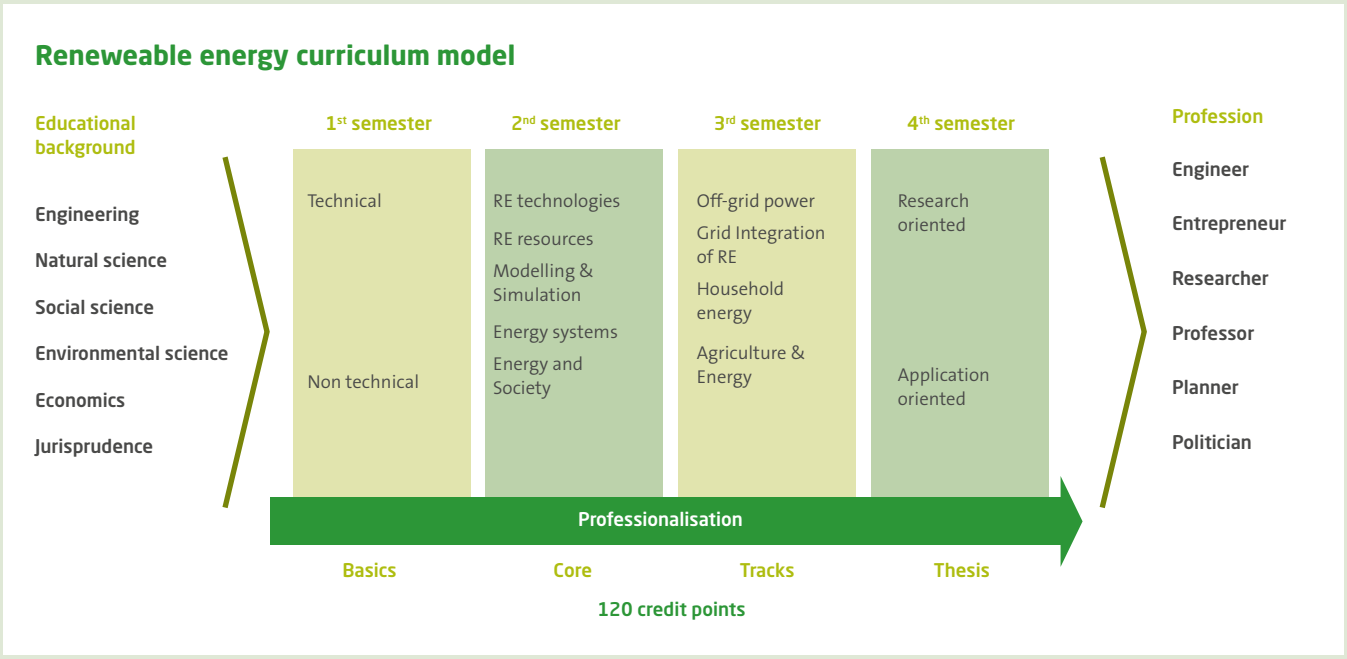

Figure 1 Renewable Energy Curriculum Model (RECP, 2015)

CHAPTER 2 UNIVERSITY PROGRAMMES AND ELEARNING FOR RENEWABLE ENERGY

2.1 Renewable Energy Curricula[8]

Renewable energy markets in Africa undergo rapid changes. In order to enter the job market, for example as renewable energy entrepreneurs or policy-makers, graduates of renewable energy higher education programmes have to be highly flexible and innovative. Therefore, renewable energy programmes need to offer a broad curriculum, often straining the university's human and financial resources[9].

Picture 3 illustrates a renewable energy curriculum model providing a "strategic approach for renewable energy Master programmes, based on theoretical consideration and empirical analyses". The study on higher education for renewable energy in Africa conducted by RECP gives more details about components of the structure and components of the curriculum.

Courses at the undergraduate level are not designed to address problems in renewable energy. The lack of qualified teaching staff and scarce financial resources are the two major hindrances to effective and sustainable renewable energy higher education in Africa.

For now, throughout Africa there are only a limited number of Master's programmes on the ground or in the planning phase in the sector of renewable energy. They differ significantly in the stage of development, teaching and content profiles, financing structure and experience.

As such, the offered programmes range from certificate courses to full degree courses. Even fewer African higher institutions offer both graduate and postgraduate programmes.

Annex 1 displays a list of 35 African universities or institutions that offer teaching in renewable energy. The table contains an already existing list of universities identified in the frame of a study conducted by the RECP.

8 Source: (RECP, 2015).

9 See also RECP's study on "Higher Education for Renewable Energy in Africa": http://www.euei-pdf.org/en/recp/action-area-4-innovation-and-skills-development/higher-education-for-renewables-in-africa

2.2 Renewable Energy eLearning Programmes at African Universities

Given the challenges of higher education for renewable energy in Africa, one way to change the status quo is to supplement the existing face-to-face traditional education with eLearning. It is assumed that by offering eLearning courses, access to higher education can be increased by reaching large numbers of students and professionals in multiple sites simultaneously (Agenda 2063). As eLearning, open and distance learning are not bound to a specific place and time, students have more flexibility in organising their studies and can tailor it to individual needs and circumstances. Furthermore, eLearning infrastructure and partnerships allow students to access knowledge of external actors.

While several African universities do engage in eLearning and many universities in Africa offer study programmes in the field of renewable energy, only few offer eLearning courses or programmes in this field. The currently existing programmes range from free webinars to full degree programmes.

Country/Region	Institution	Programme	Approach	Link
Pan-Africa	African Virtual University	Certificate Renewable Energy	Online	http://www.avu.org/avuweb/en/courses/renewable-energy/
Algeria	CDER	Renewable energy		http://www.cder.dz/?lang=en
Burkina Faso	2iE	FPL 2iE-Taxi Brousse Low-Cost	Blended learning	http://fpl.2ie-edu.org/login/index.php
Ghana	KNUST College of Engineering	Short Courses in Renewable Energy	Online	https://energycenter.knust.edu.gh/
Ethiopia	Jimma University Institute of Technology	M.Sc in Sustainable Energy engineering	Blended learning	https://www.ju.edu.et/programmes
Nigeria	National Open University of Nigeria	Bachelor Environmental Science and Resource Management (ESM)		http://nouedu.net/programmes/bsc-environmental-science-resource-management

Table 1 Examples of African higher education institutions offering virtual education programmes related to renewable energy

2.3 Renewable Energy eLearning Programmes at European Universities

eLearning programmes provided by European institutions offer a wide series of programmes and courses. The following table presents selected examples of eLearning programmes related to renewable energy higher education in Europe. The list of programmes presented is extendable and was based on an online survey distributed amongst practitioners in the field of higher education for renewable energy.

Table 2 Examples of universities in Europe engaged in eLearning in renewable energy

Country	Institution	Programme	Link
Austria	Graz University of Technology	Master of Engineering in Hydropower	https://www.tugraz.at/en/studying-and-teaching/degree-and-certificate-programmes/continuing-education/part-time-masters-programmes-and-university-programmes/hydropower/
Austria	Management Center Innsbruck	Environmental, Process & Energy Engineering	https://www.mci.edu/en/study-program/master/environmental-process-energy-engineering
Germany	University Oldenburg	Master Programme Renewable Energy	https://www.uni-oldenburg.de/en/reo/
Germany	Frankfurt School of Finance & Management	Certified Expert in Climate & Renewable Energy Finance	http://www.frankfurt-school.de/linked/en/courses/renewable-energy.html
Germany	RENAC (The Renewables Academy)	MBA Renewables	http://www.renac.de/en/masters-degrees/mba-renewables.html
Germany	SRH Hochschule Berlin	B.Sc International Business Administration with focus on Renewable Energy	https://www.srh-hochschule-berlin.de/de/studium/bachelor/international-business-administration-focus-on-renewable-energy/
Germany	Uni Freiburg & Fraunhofer ISE	Solar Energy Engineering	http://www.study-solar.com/
The Netherlands	Open University of The Netherlands	Energy Analysis	https://www.ou.nl/web/english/energy-analysis
The Netherlands	University of Eindhoven (Blended)	MSc. Sustainable Energy Technology	https://www.tue.nl/en/education/tue-graduate-school/masters-programs/sustainable-energy-technology/
Spain	Centro Universitario Internacional de Barcelona	Master of Science in Renewable Energy and Energy Sustainability	http://www.ub.edu/web/ub/en/estudis/oferta_formativa/master_universitari/fitxa/R/MD703/index.html
Spain	Fundación Universitaria Iberoamericana	Master in Renewable Energy	http://www.funiber.us/knowledge-areas/environmental-studies/master-in-renewable-energy/
Sweden	University of Gävle	MSc. Energy Engineering Online	http://www.hig.se/Ext/En/University-of-Gavle/Education/Programmes/Programsidor/Avancerad-niva/Master-Programme-in-Energy-Engineering-Online-60-cr.html
United Kingdom	Cifal Scotland	e-Learning Courses in Renewable Energy for Developing Countries	https://www.unitar.org/event/full-catalog/cifal-scotland-renewable-energies-developing-countries-environmental-necessity-economic
United Kingdom	Loughborough University	Master in Renewable Energy Systems Technology	http://www.lboro.ac.uk/study/postgraduate/programmes/taught/renewable-energy-systems-technology/
United Kingdom	Open University	Renewable Energy Module Bachelor of Engineering	http://www.openuniversity.edu/courses/qualifications/details/t313?orig=q78
United Kingdom	Ulster University	Renewable Energy Management	https://www.ulster.ac.uk/courses/course-finder/201718/renewable-energy-and-energy-management-13572

2.4 Examples of Online Programmes for Renewable Energy

The Open University and the Loughborough University are two renowned universities that provide eLearning programmes in the field of renewable energy. Due to their prominence in this field they will be further assessed. Hence, the following describes the development of the curricular, as well as the lessons learnt and the avenues for collaboration.

PROJECT EXAMPLE:

The Open University[10]

The Open University offers the following energy related programmes:

- Bachelor of Engineering (Degree)
- Energy and Sustainability module – undergraduate (30 credits)
- Renewable Energy Module – undergraduate (30 credits).

Programme costs vary. For undergraduate programmes the same costs apply for every student. The costs are congruent to UK undergraduate tuition fees. At Master's level, non-UK based students pay between £10,743–£12,406 for Energy and Technology programmes and between £11,071 and £13,089 for Environment, Development and International Studies programmes. For diploma, certificate or single module courses, less tuition fees apply.

The module is supported by a learning management system to manage teaching and learning processes of the module.

The OU is keen on partnerships with other organisations to deliver courses, collaborate on new curricula, as well as to validate programmes and share expertise: With a licensing partnership, partner universities can utilise and flex the existing courses and methods of the OU to their exact requirements. A teaching partnership with OU enables a joint delivery of Open University courses and qualifications to international students.

Given the international student profile of the OU, the modules provide limited scope for adapting the course content to suit the local needs of the students. However, in order to achieve maximum suitability, the modules are developed by multi-disciplinary course teams comprising academics, educational technologists, media specialists, respected academics and external examiners.

10 Information in this section relies on the Open University website: http://www.openuniversity.edu/courses/modules/t313

Renewable Energy Module - Study Level 3	30 Credits
An introduction into renewable energy	Overview of the current status of renewable energy in the context of the world's present primary energy situation
Solar thermal energy	Overview of the physics of solar heat and how this may be captured in a variety of different ways, as well as the complex topic of passive solar heating
Solar photovoltaics	A structured introduction to this critical technology, starting with the physics of crystalline silicone to issues of integration and future prospects
Bioenergy	Various bioenergy products and processes, illustrated with a range of practical examples examining the factors that are likely to affect the uptake of bioenergy systems
Hydroelectricity	A critical look at small- and large-scale hydro in terms of their respective benefits and penalties
Tidal power	Including barrages, lagoons and the rapidly emerging and potentially significant tidal current technologies
Wind energy	A detailed overview of a wide range of aspects of one of the fastest growing energy technologies globally that is set to become a major generator of electricity throughout the world
Wave energy	Basic principles and detailed technology case studies and a review of the most promising future designs for this potentially significant global source of renewable energy
Geothermal energy	Why it is treated as renewable even though it is being mined, its usage over the last century and its future
Integrating renewable energy into energy systems	A detailed look at the conditions under which various renewable energy sources can make an increasingly significant contribution to energy needs worldwide

Table 3 Module set up for Renewable Energy at the Open University

PROJECT EXAMPLE:

Loughborough University[11]

Loughborough University has 15 years of experience in managing a distance learning MSc in Renewable Energy Systems Technology. The programme operates parallel to the full time on-campus MSc course, which has been operating for 23 years. Programme costs vary, however fees commence at £6,600 per year. The university offers the following programmes in the field of renewable energy:

» Master in Renewable Energy Systems Technology (180 credits)

or an early leave within the Master programme is awarded with:

» Postgraduate diploma in Renewable Energy Systems Technology (120 credits)

» Postgraduate certificate in Renewable Energy Systems Technology (60 credits).

The module is supported by a learning management system to manage teaching and learning processes of the programme (online tutorials, assignments and computer aided assessments) live streamed and recorded lectures, virtual and remote labs for practical exercises.

According to Dr Sheryl Williams, Flexible and Distance Learning Manager at Loughborough University, one key challenge is the interaction of students and lecturers and the distant learning team's support of the programme. It is important to use innovative ICT to ensure student engagement and sound pedagogy. To tackle this problem, Loughborough University has developed a Photovoltaic Remote Laboratory for distant learning students – enabling students to conduct experiments from their computer.

Table 4 RE Systems Technology curriculum at Loughborough University

Master in Renewable Energy Systems Technology (180 credits)	
Compulsory Modules	**Optional Modules (student must choose three)**
Module 1: Sustainability and Energy Systems	Module 1: Advanced Solar Thermal
Module 2: Integration of Renewables	Module 2: Advanced Photovoltaics
Module 3: Solar 1	Module 3: Wind Power 2
Module 4: Wind 1	Module 4: Energy Storage
Module 5: Water Power	Module 5:Energy System Investment and Risk Management
Module 6: Biomass	
Module 7: Research Project	

11 Information relies on the website of Loughborough University http://www.lboro.ac.uk/?external, as wells as on an interview conducted with the distant learning team of Loughborough University.

CHAPTER 3 NON-UNIVERSITY RENEWABLE ENERGY ELEARNING RESOURCES

This chapter explores online courses/ programmes, Open Educational Resources (OER) and Massive Open Online Courses (MOOCs) related to renewable energy offered by institutions not yet mentioned in this study. While Open Educational Resources are more likely to be used by lecturers who seek to improve their teaching courses, MOOCs are online courses offered for a defined time period and mainly target students.

3.1 Non-university Renewable Energy eLearning Courses and Programmes

A large number of non-academic institutions and organisations offer short- and long-term open courses on renewable energy that are accessible to students, graduates, and any interested individuals. Programme offers range from certificates to capacity building courses to webinars and diploma courses.

Institution	Type of Offer	Programme	Course	Target Group	Link
Alison	Free online course	Diploma in Sustainable Development	27 Modules related to Sustainable Development including renewable and non-renewable energy sources	Professionals in the area of environmental science, students or the individual student	https://alison.com/courses/Diploma-in-S
Alison	Free online course	Renewable Energy Sources	11 Modules related to renewable energy	Teachers and students who want to learn more about energy use and how renewable sources of energy will be of vital importance for a sustainable future	https://alison.com/courses/Renewable-Energy-Sources
UNIDO (United Nations Industrial Development Organization)	Free online training programme	Capacity Building Programme in Renewable Energy	7 Modules related to RE » Energy and Climate Change; » Small Wind Energy; » Biogas; » Small Hydro Energy; » Photovoltaic Energy; » Solar Thermal Energy; » Energy Efficiency in Buildings	All individuals interested in renewable energy and sustainability	http://www.renenergyobservatory.org/capacity-building-programme.html
Climate-KIC (Knowledge and Innovation Communities)	Free online course	New massive open online course on renewable energy innovation	Renewable energy	All individuals interested in renewable energy and fighting climate change	https://learning.climate-kic.org/courses/rei-mooc
L^{3}EAP	Free online course	Energy security, access and efficiency	Sustainable Energy for SID	All individuals interested in renewable energy for developing states	http://project-l3eap.eu

Table 5 Examples of non-university elearning courses and programmes

3.2 Open Educational Resources

Name	Courses	Status	Repository/Website
Merlot	10 courses related to RE	Open	https://www.coursera.org/courses?query=renewable%20energy
MIT Open Course Ware	11 courses related to RE	Open	https://www.edx.org/course?search_query=renewable+energy
NovoEd	1 course related to RE	Open	http://online.stanford.edu/course/economics-competing-energy-technologies
Open2Study	3 course related to RE	Open	https://www.open2study.com/search/site/renewable energy
Udemy	3 course related to RE	Open	https://www.udemy.com/

Table 6 Examples of Open Educational Resources

Open Educational Resources (OER) are freely accessible, openly licensed documents and media that are useful for teaching, learning, and assessing as well as for research purposes. A list of courses in renewable energy available on main OER repositories is provided above.

The MIT Energy Initiative represents the MIT hub for energy research, education, and outreach. "The Initiative has devised an undergraduate Energy Studies Minor, which develops the expertise needed to reshape how the world uses energy. The heart of the Energy Students Minor is a core of foundational subjects in energy science, technology, and social science, complemented by a programme of electives allowing students to tailor their Energy Minor to their particular interests" (MITEnergy, 2016). More than thirty educational contents of the initiative are available as Open Educational Resources (MITEnergyOER, 2016).

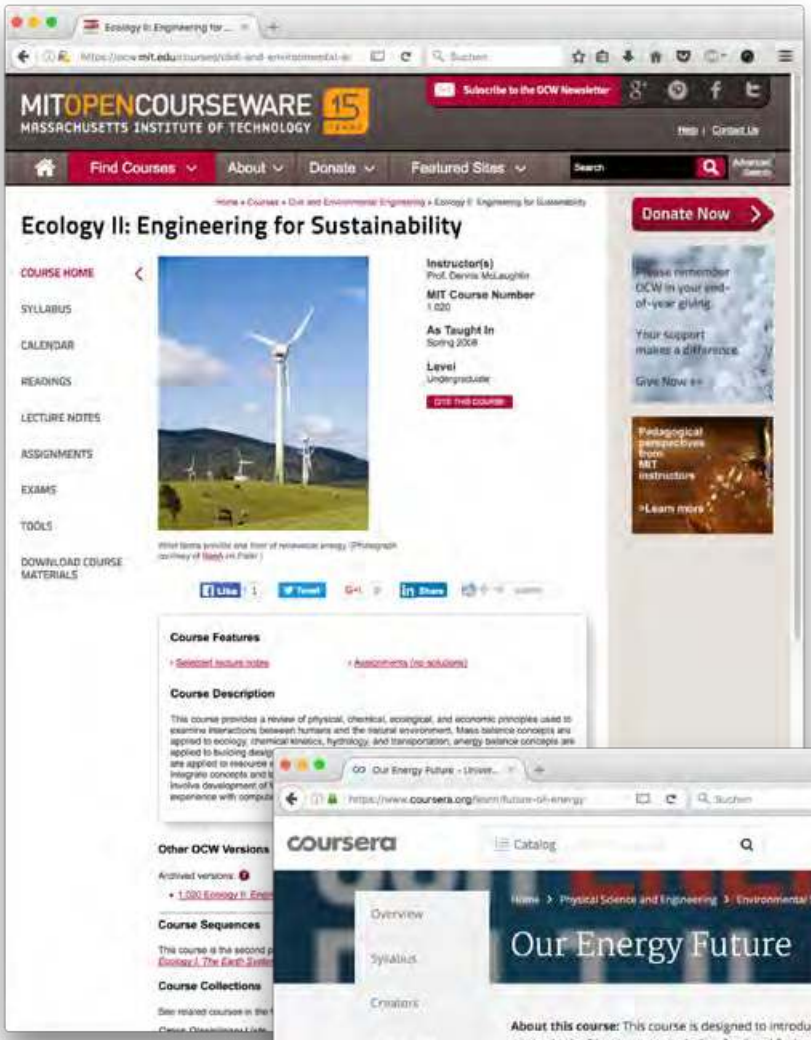

Figure 2 MIT Open Course Ware: Ecology 2: Engineering for sustainability (MIT, 2016)

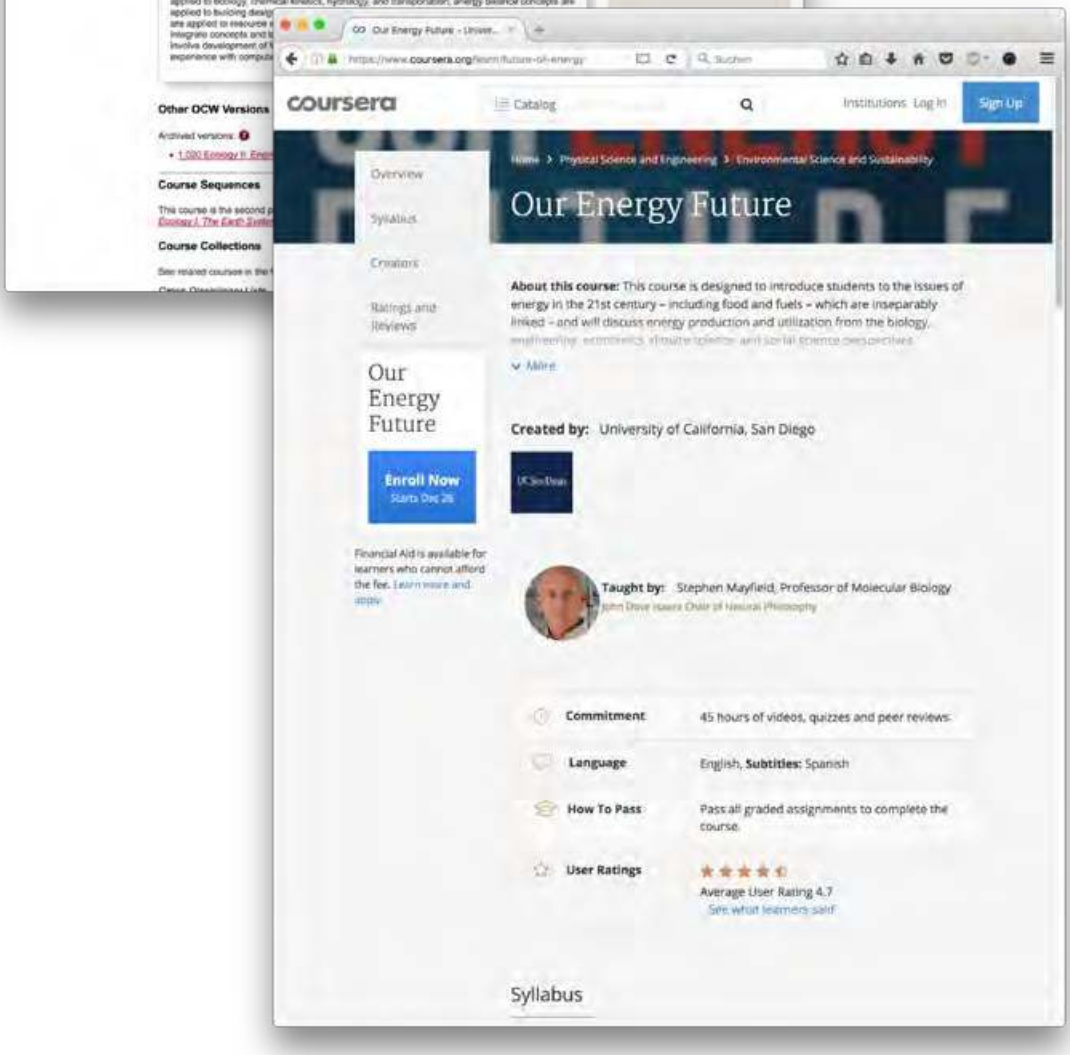

Figure 3 MOOC Our Energy Future (Coursera, 2016)

3.3 Massive Open Online Courses (MOOCs)

Massive Open Online Courses (MOOCs) are online courses that take place in a fixed time period and target masses of students. In general, there are no fees or formal requirements to attend the course and depending on the provider, minimal fees can be requested to issue certificates. While completion rates are low, owing to varying motivations for enrolling in MOOC providers, absolute numbers of participants attending these courses are usually high. While access to the course material is free, MOOC platform providers often offer certificates of completion at a cost.

The following table presents a collection of the largest MOOCs and the courses offered in renewable energy.

Table 7 A list of the largest MOOC providers and the course offers related to Renewable Energy

Name	Courses	Status	Website
Cousera	19 courses related to RE	Status	https://www.coursera.org/courses?query=renewable energy
EdX	11 courses related to RE	Open	https://www.edx.org/course?search_query=renewable+energy
Udacity	No courses related to RE	Open	https://www.udacity.com/courses/all
Iversity	1 course: The Energy Transition	April 2016	https://iversity.org/de/courses/power-up-english-for-the-energy-transition-march-2016

PROJECT EXAMPLE:

MOOC Powering Agriculture — Sustainable Energy for Food

The global initiative "Powering Agriculture: An Energy Grand Challenge for Development (PAEGC)" and the TH Köln – University of Applied Sciences jointly offered the MOOC "Powering Agriculture – Sustainable Energy for Food" in early 2016. The eight-week course introduced technical as well as economical aspects of projects at the interface of energy and agriculture. 1,354 participants registered for the course, of which 40% were from sub-Saharan Africa. 18% earned the final MOOC certificate. To receive the course certificate, participants had to continuously contribute to the course by completing weekly quizzes, community activities, assignments, and a final quiz. The platform and material remains accessible at (PowerAgri, 2016).

Table 8 Contents of MOOC Powering Agriculture

Introduction	Week 1	Introduction to the Energy-Agriculture Nexus
Renewable Energy Technologies and Energy Efficiency in Agricultural Value Chains	Week 2	Renewable Energy Resources and Technology Overview
	Week 3	Bioenergy for Agricultural Value Chains
	Week 4	Engergy efficiency in Agriculture
Economics fo the Energy-Agriculture Nexus	Week 5	Engergy and Agriculture on the Macro Level
	Week 6	Engergy and Agriculture on the Micro Level
	Week 7	Business Models for Energy and Agriculture Projects
Summary	Week 8	Summary

CHAPTER 4 EDUCATIONAL TECHNOLOGY FOR RENEWABLE ENERGY HIGHER EDUCATION

According to Aziz (2016), educational technology "is the considered implementation of appropriate tools, techniques, or processes that facilitate the application of senses, memory, and cognition to enhance teaching practices and improve learning outcomes". This chapter gives an overview on IT supported tools, techniques and processes respectively learning technologies to enhance learning/teaching practices and improve learning outcomes in the context of a renewable energy curriculum.

4.1 From Face-to-Face to eLearning/ Blended Learning Curricula

The table below summarises learning technologies, which could be used to transform a traditional didactic face-to-face curriculum into a blended or eLearning programme or into a curriculum for renewable energy.

Table 9 From face-to-face to eLearning and blended learning curricula

Learning Technologies to Support Renewable Energy Curricula		
Theoretical Courses/Units	**Didactical Approaches**	**Learning Technologies**
Core Course: Introduction to Energy, Materials Sciences, Energy Conservation and Storage, Energy Systems (bio/solar/wind/hydro/geothermal/ maritime, etc.) Elective-Transdisciplinary: Entrepreneurship; Communication, Marketing and Networking; Academic Writing; Ethics and Leadership; Research methods	Lectures/Tutorials/ Seminars	Online/Live Meeting Systems; LMS; MOOC; Webinar; eLecture Systems
	Exercises	eAssessment tools (LMS or other systems) according to specific exercises: Multiple choice, short-answer, jumbled-sentence, crossword, matching/ordering gap-fill, drag and drop
	Labs	Simulation; Remote Labs; Open Do It Your Self (DIY); Appropriated experiments kits
Single/joint Project Master Thesis	Problem analysis/ Literature research	Digital library
	Case study/Field work	Simulation
	Essay/Report	Documents management (LMS or other tools); document sharing and editing
	Presentation/Defense	Online/Live Meeting Systems
Internship	Report	Documents management (LMS or other tools); document sharing and editing
Curricular	Face-to-Face	eLearning

4.2 Reference Architecture of a Virtual or Digital Learning Environment

Ideally, the learning technologies presented in Table 9 should be integrated into a common electronic platform in order to construct a Digital or Virtual Learning Environment. In the framework of this study, a Virtual or Digital Learning Environment (VLE or DLE) is defined as a technical platform, which brings together a range of resources and tools to support teaching and learning processes. These systems or platforms include tools for student management, instructional design and delivery of resources and materials, assessment, student tracking, collaboration and communication tools, management of information systems, learning resources, repository or digital libraries.

The sketch below illustrates an example of the architecture for a Virtual/Digital Learning Environment with its respective components/ tools to support teaching and learning.

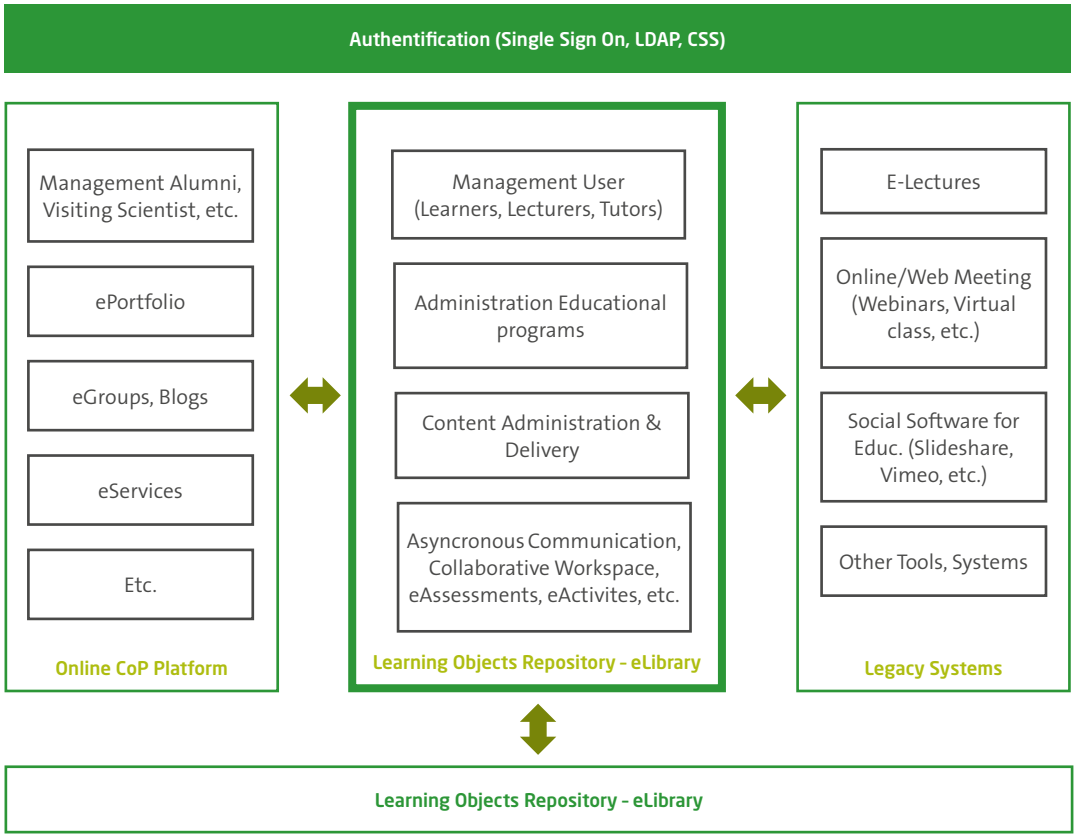

Figure 4 Reference Architecture Virtual/ Digital Learning Environment at PAUWES

Accessibility: Institutions of higher education in Africa are facing the reality of a digital divide with regards to access and use of internet due to economic and social inequality. The Digital Learning Environment in the African context should consider these realities and components. Especially tools of the DLE should provide services and functionalities accessible without requiring an internet access (offline) on a personal device or in an intranet environment. Content of the digital library or eLectures respectively video based resources should be downloadable or accessible via the institution's intranet. Several technologies such as "Web Caching and Replication" can be used to implement the approach.

The architecture of the virtual learning environment consists of following components/tools:

Higher Education Institution Portal: This component serves as a website of the higher education institution offering general information and its programmes/curricula. The Learning Management System should be accessible from the portal. In case an intranet environment is additionally provided, an authentication mechanism should be implemented to access all components of the digital learning environment. Open source Content Management Systems such as Wordpress, Drupal, Joomla, SPIP[12] or TYPO3 are mostly used in African universities.

Online/Offline Learning and Authentication: The digital learning environment as a platform, which integrates different components, should designate a single-sign-on to allow users to log into the several components/tools of the environment, using only one pair of username and password. A central user database or directory combined with a central authentication service can be used to implement the single-sign-on approach. Open source components such as LDAP[13] (Lightweight Directory Access Protocol) and CAS[14] (Central Authentication Services) are mostly used to implement the approach.

12 SPIP: http://www.spip.net/

13 OpenLDAP: http://openldap.org

14 Central Authentication Service (CAS): https://wiki.jasig.org/display/CAS/Home

Learning Management System (LMS): The LMS is a web-based software system that assists teachers to manage courses and deliver lessons online. At times it is called course management system or virtual learning environment. It supports the administration, tracking, reporting of learning processes and managing of stakeholders who are involved in learning/teaching processes (lecturers/teachers, students, course managers, etc.). The LMS also includes collaborative and cooperative learning facilities (document sharing, wikis, etc.), eAssessments tools, communication tools (discussion fora, chat rooms, etc.), event schedules and announcements. Open Source solutions are mainly used and recommended for African Higher Education institutions because of the costs, adaptation to specific requirements and support from a wide online community. Moodle[15] and Claroline[16] are the most used solution. (COL, 2004) presents the main criteria for evaluating the selection of a LMS.

Moodle is a knowledge management tool for students, which manages learning related data for educational institutions. Moodle facilitates and supports registering students in courses,

15 Moodle: https://moodle.org

16 Claroline: http://www.claroline.net/

PROJECT EXAMPLE:

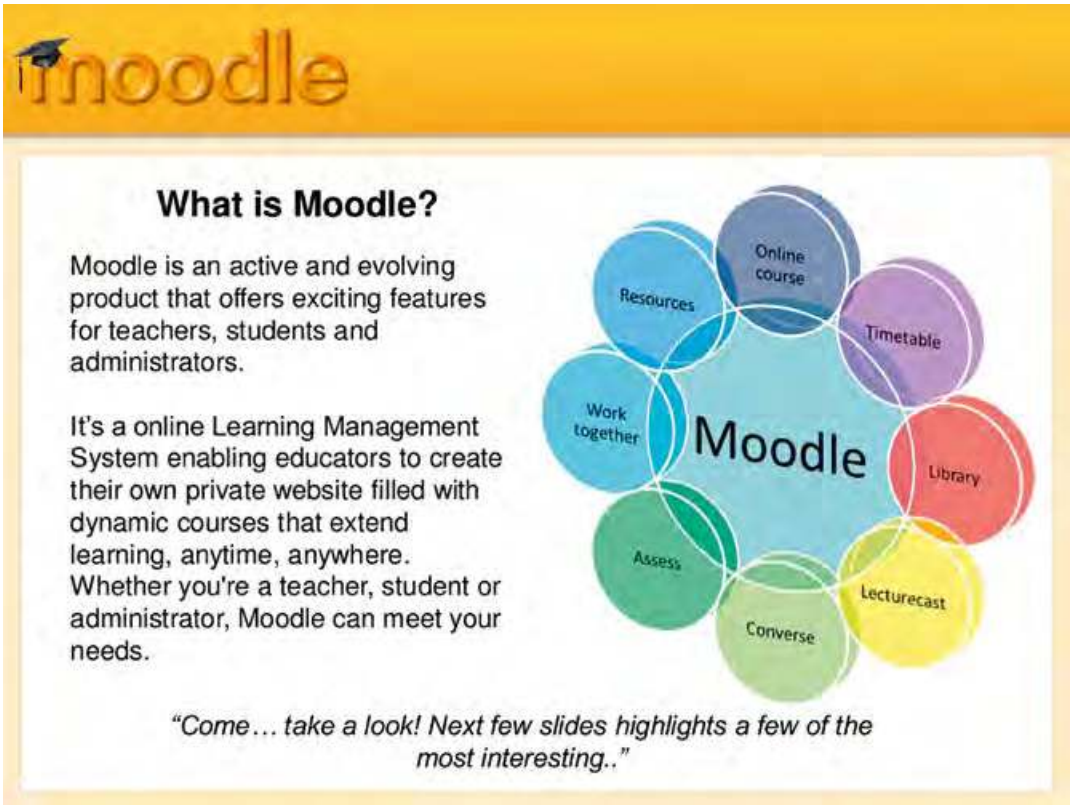

Figure 5 Moodle as an example of a Learning Management System (Moodle, 2016)

document grading, transcripts and results of students' tests, tracking students' attendance as well as managing other student related data needs in the educational context.

eLibrary and OER Aggregator: The eLibrary reconstructs the content and services of a traditional library in digital form. An OER aggregator aggregates Open Educational Resources from multiples sources and can be linked/integrated with the eLibrary. A learning object repository can be integrated into the eLibrary as an online tool for storing, managing, and sharing learning resources (learning objects) to support the lecturer in the design of eLearning courses. A learning object is an artefact (like a quiz, a presentation, an image, a video, or any other kind of document or file),

Figure 6 Fraunhofer ePrints (Fraunhofer, 2016)

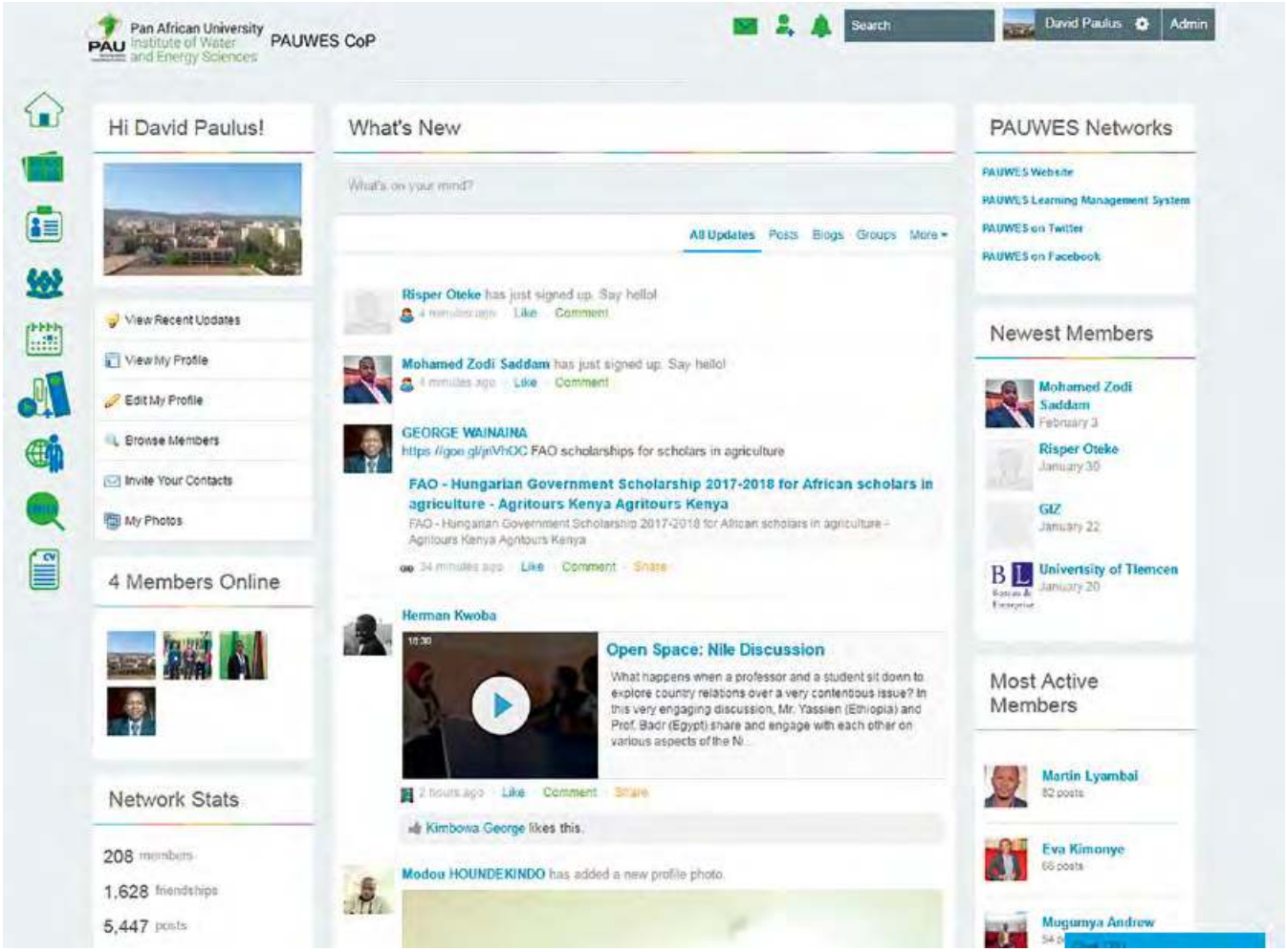

Figure 7 PAUWES Social and Professional Networking Platform (PAUWES, 2016)

which can be used to create course content and learning materials for online learning, eCourse or eResource. Open source platforms such as EPRINTS, DSPACE, FEDORA, GREENSTONE can be used to implement the eLibrary.

Social and Professional Networking Platform: A platform to connect and support the interaction, communication, information and resource sharing, cooperative and collaborative processes amongst stakeholders involved in activities and processes at the higher education institutions (e.g. students, alumni, lecturers, visiting scientists, experts, private sectors, institutional partners). This component provides the appropriate tools and resources to build an online community from a practical perspective. Open source solutions as ELGG[17], NING[18], and Social Engine[19] can be used to implement the social and professional networking platform.

17 Elgg: http://elgg.org

18 Ning: http://www.ning.com

19 SocialEngine: http://www.socialengine.com

Online/Live Meeting Systems support the synchronous/live communication amongst distributed stakeholders (lecturer and students) for online lectures, web meetings, webinars and other live events online. Big Blue Button, OpenMeetings, Adobe connect and ZOOM[20] are some solutions used in the African context.

Figure 8 Live Meeting System by Adobe Connect

20 BigBlueButton: http://bigbluebutton.org
Apache OpenMeetings: https://openmeetings.apache.org
Adobe Connect: http://adobeconnect.eu
Zoom Videoconferencing: https://zoom.us

eLecture System is a tool to support the recording, management/administration and dissemination of video based lectures, called E-Lectures, Vodcast/Podcast. OpenCast is an open source software that can be used to implement an eLecture system.

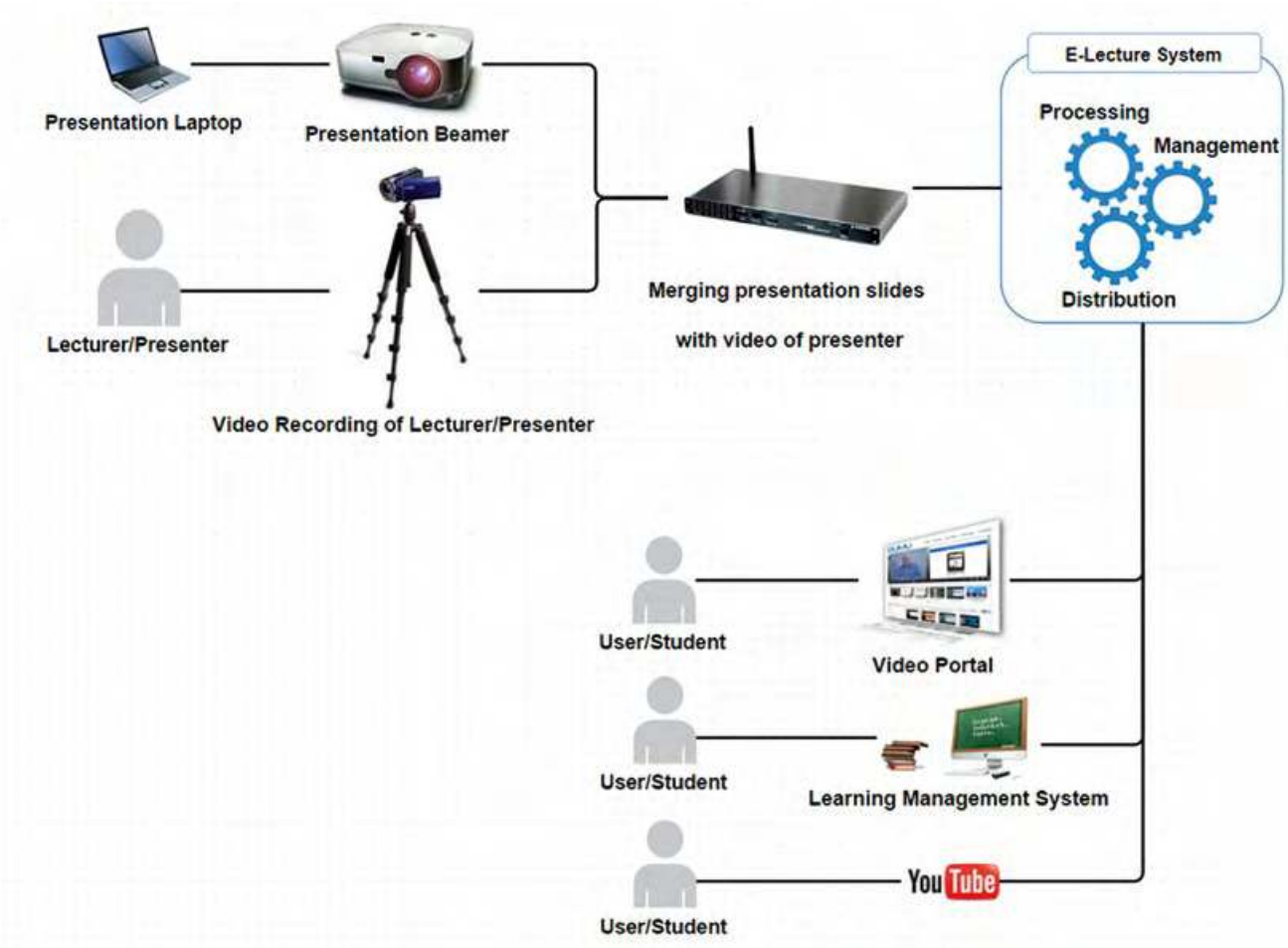

Figure 9 Opencast for Lecture Recordings

Social Software: Several tools according to specific requirements such as Dropbox for file management, SlideShare for online slides/ presentations, WhatsApp for asynchronous communication, Google Docs for the shared editing of office documents can be integrated to the Digital Learning Environment.

4.3 Learning Technology to Support Practical Exercise in Renewable Energy Education

The main challenges institutions of higher education in Africa face are poor physical facilities and infrastructure for practical training and lab exercises. Many of the institutions have seen little or no infrastructure improvements for the last decades due to insufficient budget and overdependence on public budget. The development of information and communication technology, the constant development of capacities of hardware devices and their affordability in terms of costs provide new opportunities to develop solutions for access to physical facilities and infrastructure for practical training and lab exercises. The following paragraphs present some approaches to address the problem:

Simulation and Virtual Laboratory

The Virtual Laboratory is an interactive environment for creating and conducting simulated experiments. In this virtual laboratory environment students can then solve real-life problems with provided computers. Below, the virtual lab environment of 3M provides an example for an engineering design problem in the field of Wind Energy. Here, students "must define the problem, determine the design requirements and constraints (including cost per

APPLICATION EXAMPLE

Figure 10 3M Wind Energy Virtual Lab (3MVLabs, 2016)

APPLICATION EXAMPLE

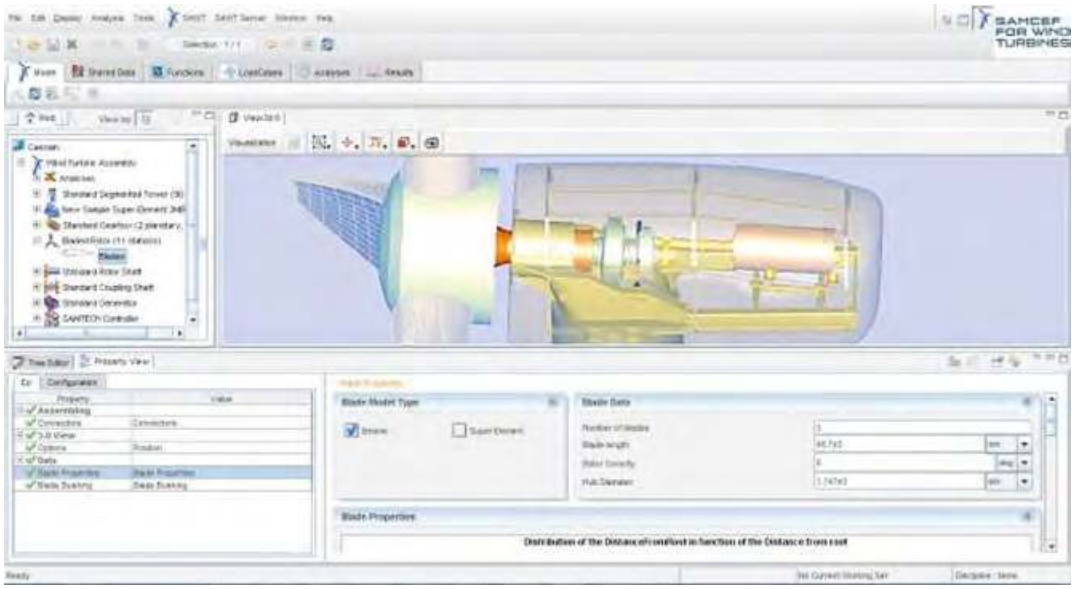

Figure 11 Siemens PLM Virtual Labs Environment (Siemens, 2016)

watt of power produced), brainstorm solutions, do research, build and test a prototype, and collect data in a systematic way" (3MCourse, 2016).] The lab will generate data they need in order to evaluate their designs and perhaps make design changes and retest until satisfactory results are achieved.

Virtual Reality and Augmented Reality

Virtual reality or virtual realities (VR), "also known as immersive multimedia or computer-simulated reality, is a computer technology that replicates an environment, real or imagined, and simulates a user's physical presence and environment to allow for user interaction. Virtual realities artificially create sensory experience, which can include sight, touch, hearing, and smell" (Isaac, 2016).

Augmented Reality (AR) is a live direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data. It is related to a more general concept called "mediated reality", in which a view of reality is modified (possibly even diminished rather than augmented) by a computer. As a result, the technology functions by enhancing one's current perception of reality (Graham et al., 2012). By contrast, virtual reality replaces the real world with a simulated one (Steuer, 1993).

Both technologies can be used separately or in combination to support practical teaching to replicate lab exercises or experiments in renewable energy.

Figure 12
Virtual Reality illustration (Catapult, 2016)

Figure 13 Augmented Reality illustration (Skope-Groupe, 2016)

Remote Labs

The Remote Laboratory is an environment in which experiments are conducted and controlled not by direct manipulation of laboratory equipment, but by means of a computer, that is linked up to the actual laboratory equipment via a network.

Loughborough University has launched the most advanced PV remote lab for distant students. With this new apparatus, students are able to conduct experiments from their computer. By manoeuvring and changing the PV panel, temperature and irradiance intensity, they can see the effects for themselves, in real time, via laboratory webcam. From a technical perspective, the remote lab at Loughborough University can be used by institutions/actors around the world, which are equipped with appropriated internet connection.

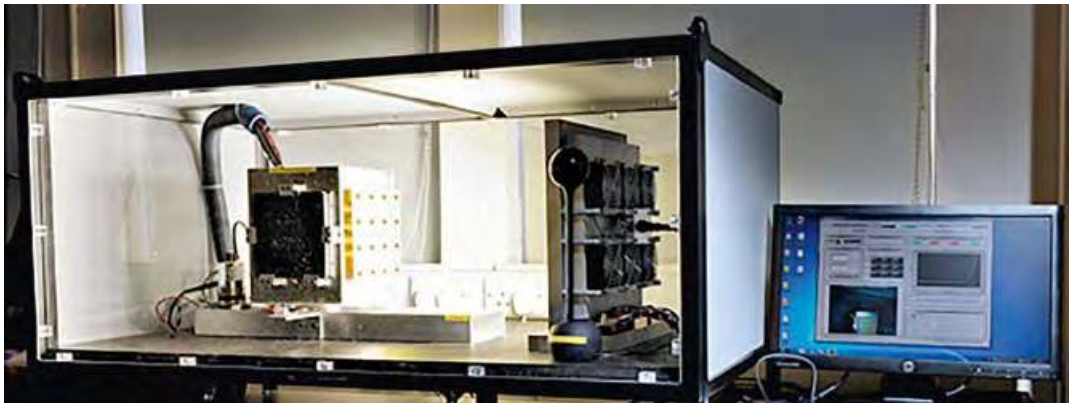

Figure 14 Example of Remote Labs at Loughborough University (Loughborough, 2016)

Low cost kits for renewable energy experiments

The decrease of costs regarding the accessibility of electronic components such as micro-controllers and sensors provide new opportunities to design and develop appropriate low-cost solutions as embedded systems to support lab exercises or experiments in renewable energy education.

Open Do It Yourself/Open Source experiments

Multimedia based "Do it Yourself Online Tutorials" for renewable energy that make use of low cost materials available online, could also be used for lab exercises regarding experiments to strengthen practice oriented teaching in institutions of higher education in Africa. The tutorials are mostly available under creative common licenses and many are supported by video instructions.

APPLICATION EXAMPLE

Figure 15 Renewable Energy Experiment Kits (Elektor, 2016)

CHAPTER 5 POTENTIAL, OUTLOOK AND RECOMMENDATIONS

5.1 Potential of and Outlook for Renewable Energy and eLearning in Africa

Over the years many governments have come to appreciate the role of renewable energy for sustainable development. However, a number of barriers continue to impede the potential of renewable energy. One of the most significant barriers is the lack of skilled human capital to implement renewable energy technologies.

The use of innovative educational technologies is one solution to improve the quality of teaching and to accelerate human capital skills. Hence, eLearning can bridge the knowledge deficit in this field and promote high quality education in renewable energy studies.

Educational technology enhanced learning and training has the potential to transform the face of Africa. Over the past seven years, the eLearning community in Africa has grown in leaps and bounds. This becomes visible when looking at the growing number and variety of participants attending African eLearning conferences each year as well as increasing numbers of eLearning programmes, research initiatives, partnerships and organisations in Africa.

Despite this, there is a lack of awareness for the effectiveness of eLearning in the field of renewable energy and its benefits in higher education. Even if the number of distance learning curricula in renewable energy that were implemented by African institutions of higher education is still marginal, many lecturers already make use of educational technologies to improve their courses.

Students of higher education institutions in Africa have access to a wide scope of courses and programmes ranging from webinars, advanced training, certificate and diploma courses through the internet. Massive Open Online Courses are proposed by educational institutions and other providers and extend the possibility to strengthen the capacity of students of renewable energy in Africa. Open Educational Resources developed by renowned institutions such as the MIT provide a good basis for lecturers in African institutions of higher education to enhance their respective courses.

The increase in internet accessibility in Africa through cost reductions provides an excellent basis for the implementation of digital learning environments to support renewable energy higher education programmes. Chapter 4 of the study presented a reference architecture for the set-up of such an environment with the most used open source tools and technologies in the African context. The development of information and communication technology, as well as the constant development of capacities of hardware devices and their affordability in terms of costs provide new opportunities to develop solutions to address one of the main problems of renewable energy higher education in Africa. This is mainly the lack of physical facilities and infrastructure for practical training and lab exercises.

Activities, programmes and services of global actors in eLearning in Africa, such as the Commonwealth of Learning or Agence Universitaire de la Francophonie provide resources and means for professionals and renewable energy higher education institutions to initiate or further develop their respective activities/programmes.

Policy-makers at the national and Pan-African level can influence and positively shape eLearning for renewable energy higher education by providing the organisational and institutional frame for its acceptance and further development. Effective partnerships and collaborations can benefit this emerging sector and support African universities by creating awareness for the importance and impact of eLearning, as well as by building strong infrastructure, and by producing skilled technical and academic staff for the future of renewable energy in Africa.

5.2 Recommendations for Activities and Support Initiatives

The following table represents a set of recommendations and potential activities resulting from the RECP workshop on eLearning for renewable energy higher education[21] held during the Africa-EU Renewable Energy Research and Innovation Symposium in March 2016 in Tlemcen, Algeria. The workshop was organised in the scope of the assessment study in order to, inter alia, collect feedback on challenges as well as the potential of eLearning for renewable energy education in Africa.

21 RECP workshop on eLearning for renewable energy higher education: http://www.euei-pdf.org/en/recp/action-area-4-innovation-and-skills-development/workshop-on-elearning-for-renewable-energy

Recommendations - Activities	Geographical scope[22]	Time-frame
Content Development and Didactic		
1. Development of a set of basic eCourses to be integrated in eLearning curricula for African institutions of higher education	Local Regional	1–2 years
2. Develop a blended learning reference curriculum for institutions of higher education in Africa; further develop and adapt to specific contexts/regions	Local Regional	1–2 years
3. Development of a community of practice, regarding lecturers to interact and share resources	Local Regional Transregional	1–3 years
4. Identify a set of exercises and experiments to be improved through eLearning technologies to support practical teaching in renewable energy education	Local Regional	1 year
5. Develop a set of experiments using low cost hardware to support practical teaching through lab exercises in African institutions of higher education	Local Regional Transregional	1–2 years
6. Make use of innovative technologies such as virtual and augmented reality to address the issue of missing renewable energy labs in African universities	Local Regional Transregional	1–2 years
Infrastructure		
7. Design of a Digital Learning Environment integrating an independent source of power (renewable energy module) to address the issue of power shortage or lack of power	Local Regional Transregional	1–2 years
8. Development of a flexible kit based on renewable energy providing power to run tools and services of Digital Learning Environment	Local Regional Transregional	1–3 years
9. Implementation of models to run services and tools of eLearning environment without internet (local devices, in campus intranet, etc.)	Local Regional Transregional	1–3 years
10. Evaluate the use of mobile devices to support renewable energy education	Local Regional Transregional	2 years

22 Local: Only one institution; Regional: more than one institution; Transregional: Across sub-Saharan Africa and/or with Europeans partners.

Awareness, Change Management and Networking		
11. Further mapping of existing programmes and best practices of eLearning for renewable energy higher education	Local Regional Transregional	1 year
12. Link up renewable energy programmes with existing online based communities of practice for North-South and South-South university and stakeholder cooperation	Local Regional Transregional	1–2 years
13. Development of activities/programmes to improve the acceptance of eLearning	Local Regional	1–3 years
14. Seek collaboration partners for the design, development and implementation of eLearning activities/programmes to integrate resources and expertise	Local Regional Transregional	1 year
15. Make use of ICT to develop joint North-South-South Open Distance Learning programmes	Local Regional Transregional	1–2 years
Quality and Accreditation		
16. Development of a quality framework for the assessment of the quality of eLearning courses and programmes for renewable energy	Local Regional Transregional	1–2 years
17. Linking renewable energy eLearning programmes to existing accreditation bodies, advisably in Pan African organisations in order to standardise, harmonise, evaluate and regulate the eLearning programmes	Local Regional Transregional	1–2 years
18. Development of approaches and solutions to improve the acceptance of renewable energy eLearning degrees by employers	Local Regional Transregional	1–3 years
19. Create awareness for the use and benefit of eLearning in the renewable energy sector among policy-makers in order to increase policy relevance	Local Regional	1–3 years
eCompetences and Skills		
20. Regular eCompetence training for university staff (technical, administrative) and lecturers	Local	< 1 year
21. Conduct basic ICT training courses to acquire skills needed to explore the full potential of eLearning	Local	< 1 year
22. Make use of resources/programmes provided by global actors who are engaged in eLearning in Africa, such as the Commonwealth of Learning, Agence Universitaire de la Francophonie, etc.	Local Regional Transregional	1 year
Sustainability and Ownership		
23. Development of financial models to ensure the sustainability of eLearning programmes for renewable energy education	Local	<1 year
24. Development of models to ensure ownership of local actors, who are involved in eLearning programmes with external and international partners/donors	Local	< 1 year

ANNEX

Annex 1: Examples of African institutions that offer programmes related to Renewable Energy

Country	Institution	Name Programme	Link
Algeria	Pan African University of Water and Energy Science including Climate Change	Master in Energy	http://pauwes.univ-tlemcen.dz
Burkina Faso	2iE Ouagadugu	Master's programme in Infrastructure and Service Management, option renewable energies	http://www.2ie-edu.org/en/training-program/initial-training/masters-programs/masters-program-in-engineering-option-electric-and-energetic-engineering/
Burkina Faso	2iE Ouagadugu	Engineering Master in Electricity and Energy	-
Egypt	Zewail City	Institute for Energy, Environment and Space (IEES)	https://www.zewailcity.edu.eg/main/content.php?lang=en&alias=research_institutes
Ethiopia	Mekelle University	Master in Renewable Energy	http://cedat.mak.ac.ug/wp-content/themes/CEDAT-Theme/curriculums/msc-renewable-energy/MSc-in-Renewable-Energy.pdf
Ghana	CSIR-Forestry Research Institute of Ghana	Dual Degree Programme in Master of Science in Bio-economy and Natural Resources Management (MSc. ECORES) and Executive MBA	http://www2.uef.fi/en/ecores
Ghana	Kwame Nkrumah University Energy Center	Short term course renewable energy organised	http://www.energycenter.knust.edu.gh
Ghana	West African Science Service Center on Climate Change and Adapted Land Use	mutiple	http://www.wascal.org
Kenya	Strathmore University	Master in Renewable Energy and Electricity and Energy	https://serc.strathmore.edu
Kenya	University of Nairobi	Certificate in renewable energy	http://nuclear-sciences.uonbi.ac.ke/uon_degrees_details/190/courses/#.degree_anchor_190
Liberia	Stella Maris Polytechnic	Certificate in Sustainable RE	-
Morocco	University Rabat Morocco	Renewable Energy and petroleum studies	http://www.uir.ac.ma/en/les-formations-de-luir/energies-renouvelables-et-etudes-petrolieres
Namibia	Namibia Univerity of Science and Technology	under development	-
Namibia	Nambia Energy Institute	Soltrain	http://www.soltrain.com.za

Niger	Université Abdou Moumouni de Niam	Master in Climate Change and Energy	http://uam.refer.ne
Niger	Université Abdou Moumouni de Niam	Renewable Energy	http://uam.refer.ne
Nigeria	Imo State University	MSc in Renewable Energy	-
Nigeria	Federal University of Technology	Doctoral Programme West African Climate System	http://wascal.futa.edu.ng/about.php
NIgeria	Kwara State University	Master in Renewable Energy	http://www.kwasu.edu.ng
Rwanda	University of Rwanda	MSc in Renewable Energy	http://www.ur.ac.rw/?q=node/416
Senegal	UN African Institute for Economic Development & Planning (IDEP)	MSc in Energy Policy	h.robinson@unidep.org
Senegal	UN African Institute for Economic Development & Planning (IDEP)	Energy Policy for Development (short course, postgrad level)	h.robinson@unidep.org
South Africa	Energy Research Centre	MSc (Eng.) Energy Engineering	http://www.erc.uct.ac.za/education/prospective/masters
South Africa	Stellenbosch University	Centre for renewable and sustainable energy studies	http://www.crses.sun.ac.za
South Africa	University of Pretoria	Postgraduate programme in Energy Efficiency and Demand-side Management	http://www.up.ac.za/national-hub-for-postgraduate-programme-in-energy-efficiency-and-demand-side-management-eedsm-hub
South Africa	Nelson Mandela Metropolitan University	Advanced Mechatronic Technology Centre offers a short term course in renewable energy studies	http://amtc.nmmu.ac.za/Renewable-Energy-Short-Courses
South Africa	Central University of Technology	Higher Certificate: Renewable Energy Technologies	http://www.cut.ac.za/faculty_pages/renewable-energy-technologies/
Tanzania	University of Dar es Salaam	Master in Renewable Energy	https://www.udsm.ac.tz
Togo	Université de Lome	Materiaux – Energie	silnap@yahoo.fr
Uganda	Makerere University	Master of Science in Renewable Energy	http://cedat.mak.ac.ug/graduate-programmes/master-of-science-in-renewable-energy
Uganda	Makerere University	Centre for Research in Energy and Energy Conservation	http://creec.or.ug
Uganda	Ndejje University	MSc in Renewable Energy	cwasswasebuwufu@gmail.com +256773148692
Uganda	School of Women and Gender Studies	Renewable Energy and Energy in Engineering for Sustainable Development	http://wgs.mak.ac.ug/
Zimbabwe	University of Zimbabwe	BSc Honors in Renewable Energy	cshoniwa@eng.uz.ac.zw shocle@yahoo.com
Zimbabwe	University of Zimbabwe	MSc Renewable Energy	http://www.uz.ac.zw/index.php/eng-progms

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