

E-learning Foresight for Renewable Energy Technology in Higher Education in Morocco

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Abstract Nowadays, education strategy aims to introduce some potential approaches into teaching and learning taking into account sustainable development. Renewable energy sources represent the future utilization of energy. The use of this technology do not harm the environment because it is clean and environmentally friendly. Consequently, using E-learning platform in renewable energy education is a novel and a creative method to empower teaching for students and researchers to take action for sustainable development. This paper presents a survey of some existing E-learning platforms in energy education. As a result, it proposes to implement an E-learning platform as a beneficial and advantageous solution for developing countries such Morocco to train the needed competencies.

Keywords E-learning · Renewable energy · Green energy · Renewable energy education · Sustainable development · Moodle

1 Introduction

Development in Information and Communication Technologies (ICT) is increasingly transforming and promoting the way of learning. The new ICTs permit to optimize the modern society's requirements, so a lot of educational institutions throughout the world have developed new educational methods based on electronic, so called virtual, teaching. Nowadays, E-learning is considered as a new approach to enhance learning and training relying on ICT as a practical means of delivering and presenting educational contents. It has become of paramount importance as it covers a very large number of various educational fields by offering new and

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convivial tools helping to incorporate constructive learning strategies. E-learning provides also the possibility to personalize learning anywhere (classroom, home etc) and anytime. It meets the requirements of students according to their age and previous knowledge. Various definitions of E-learning are given in literature, [1, 2] present e-learning as communication and learning activities via electronic means and through computer and networks. E-learning is defined in [3] as self-learning through information technology. Collaborative learning is also one of the E-learning applications.

In the field of energy engineering, ICTs have been abundantly integrated practically into education programs for many years, for instance by simulation software for energy systems.

Today we primarily use fossil fuels (coal, oil, and natural gas) to meet our energy needs like heating and powering homes and also fuelling cars. However, we have limited reserves of these fuels on the Earth and we are utilizing them much more rapidly. In this context, new alternative energy sources are developed to be efficient and environmentally friendly. Renewable energy is the use of new energy sources like solar, wind, geothermal, hydro, ocean and biomass to deliver power and heat to the end-user. Using renewable energies is better for the environment because they are less pollutant. This is why renewable energy technologies are often called clean or green. Therefore, green energy means clean energy included in sustainable development plans for environment protection and free pollution [4].

In regard of the importance given to renewable energy in the world, universities are integrating and developing educational programs taking into account renewables. Renewable energy education (REE) is currently of paramount importance as it is one of the key elements of sustainable development [5]. In the meantime, advancements in ICTs have allowed the use of didactical tools to present some internet based courses on different topics such as renewable energy. The rapid advancements in these technologies have put more emphasis on this educational discipline which requires further changes. In this respect, various E-learning platforms are proposed to fulfill the educational requirements with novel methods. Experiences in other domains of study suggest that the knowledge obtained through experiments in laboratories can be gained almost equally through suitable E-learning platforms. These platforms can be usefully used to conduct some experiments in laboratory by students and can also be very helpful for teachers. In the domain of renewable energy where the founding of advanced laboratories in the developing countries may be unwieldy, a set of E-learning platforms for renewable energy increasingly facilitate high quality REE worldwide.

2 Renewable Energy in Morocco

Unarguably, the glory value of energy, as a fundamental ingredient in our daily life, has become a key element of debate on E-learning, social-media, social, economic and environmental dimensions of sustainable development.

Different kinds exist in energy like fossil-based energy, which commonly contains coal, fossil fuel and natural gas and the big part of energy is produced with this last.

The fossil fuel has given birth to some major human living system problems and human health diseases, because of their expanded use in several industrial and non-industrial sectors. Such problems are detailed in [6]. Hence, when we discuss around green energy we intend by this non-exhaustible resources produced from renewable energy sources l solar, hydro, biomass, wind, geothermal and ocean [7].

In Morocco, the majority of resources data currently in existence are used and collected as follows for an eco-friendly and economical over the long-term.

2.1 Solar Energy

According to the two Moroccan agencies, the Research Institute for Solar Energy and New Energies (IRESEN) and the Moroccan Agency for Solar Energy in Morocco (MASEN), solar energy is emerging as a major trumping in the growth and the development of the country. We don't just provide green and clean energy for our country but also the possibility of exporting energy to neighboring markets for the future.

Since 2009, His Majesty King Mohamed VI announced the launch of a National Solar initiative spotted with a budget of \$9bn in order to sustain Morocco's ambition of reaching 42 % of renewable in its energy mix by 2020. The following convention between the projects DESERTEC and NAREVA for an extra 500 MW plant is to be implemented. In addition to this, another worldwide complex solar power called NOOR is in construction in OUARZAZAT in the central south of Morocco. It is considered as the world's largest solar power plant. The whole project is divided into three parts, the gigantic one namely NOOR-I was launched in February 2016 producing 160 MW and using 5000 panels, while the two others are now under construction. NOOR is developed on 3000 hectares and is expected to produce 580 MW in the horizon of 2018.

2.2 Hydro Energy

Morocco is a country, which contains an immense and a wide renewable energy potential. This potential has been exploited early on in the shape of hydro. To give an exhaustive vision, Morocco as an agrarian economy, hydro energy sought to confer itself with an energy power to whip up its development and growth. In the early years after its independence, there was a reasonable and rationalistic option as it would avail generating energy as a byproduct and water security.

King Hassan the Second made it a national policy to construct one dam per year. As outcome nowadays, Morocco disposes of 26 hydro power stations totaling 1 360 MW in capacity. Future expansion and evolution are actually centered around micro dams and 200 potential sites have formally been defined. Actually, Al Wahda, the second largest dam in Africa is Moroccan According to IRESEN.

2.3 Wind Energy

As part of the energy strategy utilized to sustain the development of renewable energy and energy efficiency in the country, Morocco has undertaken a wide wind energy program. According to the National Agency for the Development of Renewable Energy and Energy Efficiency (ADEREE) and Ministry of Energy, Mines, Water and Environment, the total investment concerning the Moroccan integrated wind energy project over a period of 10 years was estimated at 31.5 billion dirhams. This investment will authorize the country to bring capacity based on wind energy from 280 MW in 2010 to 2000 MW in 2020.

3 Renewable Energy Education

Education plays a vital role in the sustainable development in societies. It is the cornerstone in any development strategy. It aims primarily to perform a powerful social change by raising awareness in all fields, and secondly, it also provides training for professionals namely researchers who will develop the next generation systems. In energy domain, renewable energy is evolving rapidly as an advanced academic field. Generally, REE is a relatively new area and previously it was not a major part of engineering courses. Presently, REE must be integrated into educational programs as it requires special techniques that are not normally met in other disciplines. Studying a limited number of units on renewable energy that are added into traditional science and technique courses doesn't seem probable to provide enough knowledge and skills to the graduates in order to use renewables efficiently. REE programs propose integrated packages that include various disciplines and skills such as the study of the resources, technology, design of the systems, industry, economics and policies. This gives the ability to the graduates to analyze and design systems with a range of available options and be particularly aware of industrial environment.

According to [8], engineering education and training in renewable energy have both long-term and short-term goals, and both are important. The aim of the long term is to form educated specialists at all levels in all fields of engineering and generalists whose education includes an appreciation of how renewable energy will figure in their fields. In the short term, the goal is to re-educate specialists already in the work-force. These goals need various kinds of education effort.

4 E-learning Platforms in Renewable Energy Education

New Information and Communication Technologies allow learning without limitations of place, time, occupation or age of the students. E-learning platforms offer courses that are educational concepts with technical, didactical and administrative materials to transfer the contents of any subject of knowledge. An E-learning platform is a set of tools managing the interaction between system users (students, tutors and administrators) and the distant server. Among different E-learning platforms concerning energy education we cite and present the following ones.

4.1 *RegEn-M E-learning Platform*

RegEn-M (Renewable Energy Multimedia) system is developed in the Otto-von-Guericke University of Magdeburg in Germany. The major aim of the realization of this system is to introduce the technology and implementation of the dispersed energy resources (DER) into the power system closer to the students [9]. RegEn-M platform is a web system designed to offer a didactic tool on DER technologies and to stimulate the interest of students in this field for the future of the power system.

The teaching system RegEn-M is a server-client platform; the E-learning courses remain open systems implement new materials and information in the future. The study area can be adapted to the user and the teaching contents are presented in a tree structure, which facilitates the orientation of the student during the studying. Petri Networks have been used to control and guide the students through the teaching contents. The access to the project user is possible by simply using web browsers such as Mozilla and Explorer etc.

RegEn-M platform has been conceived as a set of modules. Each module introduces a special type of DER. Different types of animations and introductory videos are realized to introduce the teaching concepts. The modules are categorized into three parts: basic principles, system technology and power network connection. Basic knowledge is presented as small text blocks, illustrated with figures, tables, graphics, animations, acoustic and non-acoustic and also simulations in MATLAB. In-depth knowledge includes additional contents of teaching, internal and also Internet links. Teaching materials are allowed to be downloaded. Each teaching part finishes with a test module that consists of a set of multiple choice questions and calculation tasks to assess the reached knowledge. Six teaching modules are available. They consist of the following topics:

Basic principles of energy production; Wind as an energy source; Photovoltaic energy production; Small water power plants; Energy storage devices; Fuel cell system.

4.2 E-learning Website Energy University by Schneider Electric

Schneider Electric, a global specialist in energy management, has launched an online educational community, Energy University. It offers the information and professional training on energy efficiency concepts. The E-learning courses aim to provide help to the specialists in this domain. Apply safe, reliable and cost-effective measures and take care of efficiency issues are the main objectives of the imparted knowledge. Typically less than 1 h to complete each course. More than 21000 users have been registered since the E-learning platform launch in June 2009.

4.3 Energy Power Lab E-learning Platform

Energy Power Lab proposes an e-learning platform focusing on the renewable energy industry including international finance, logistics, project management, etc. Besides the courses of renewable energy like solar, wind and biofuels, the fundamentals of renewable energy are taught such as thermal transfer, fluid mechanical engineering and economics of renewable energy.

Energy Power Lab can provide its E-learning service in one or a combination of the following ways: online, with support (video chat regularly with experts/instructors) and face-to-face, together with online. The proposed online courses are:

- The fundamentals of thermal transfer, fluid mechanical engineering, principles of
- electricity
- The fundamentals of the solar energy systems, photovoltaic cells and systems
- The fundamentals of the wind source, the fundamentals of biomass energy
- Grid integration and renewable energy integration
- Solar energy devices and solar energy systems
- Heat Transfer
- Bio energy
- Wind energy technology
- Energy efficiency and storage, economics of renewable energy sources.

4.4 Solar Energy International Online Courses

Solar Energy International (SEI) was founded in 1991 in United States of America as a nonprofit educational organization. It aims to offer industry technical training and teaching and also an expertise in renewable energy to empower people,

communities, and businesses worldwide. SEI proposes various online courses related to the renewable energy topics:

Why Renewable Energy?; Conservation and Efficiency; Basics of Electricity; Solar Thermal; Wind Power; Micro-Hydro; Other Renewable Energy Technologies; Appropriate Technology for the Developing World; Economics of Renewable Energy.

4.5 Distance Learning Program on Renewable Energy by TERI University

TERI University in New Delhi, India provides online programs on renewable energy education. It offers three kinds of certificates; each certificate has its related courses. The proposed diplomas are:

- Advanced PG Diploma in Renewable Energy, prepared during 2 years.
- PG Diploma in Renewable Energy prepared during 1 years.
- Certificate courses during 20 weeks.

4.6 Comparison of Platforms

In this section, we present a qualitative comparison of four E-learning platforms already cited, knowing that we do not have the external access to the RegEn-M E-learning platform to put it in comparison (Table 1).

In summary of a few qualitative points of comparison, we can say that all of these four platforms studied use either dynamic websites manually developed or CMS (Content Management System). Nowadays there are other more effective and adapted ways to learn in a distance-learning environment.

Facing the development of E-learning, standards has been created to guide its practices. Thus, the content used as part of the E-learning generally meet one or more of the AICC, IMS, SCORM, LOM and QTI. These standards have several aims, the main ones:

- Standardize the indexing of various contents
- Allow to share pedagogical content between different environments
- Ensure interoperability of content between themselves and with the E-learning platforms
- Allow the combination of basic training modules to create a customized training.

Table 1 Qualitative comparison between E-learning platforms

E-learning platforms	Used technologies (Must important)	Strong points (Must important)	Websites of platforms
Website energy university by Schneider electric	PHP 5.3.3 Apache 2.2.15.	Security, flexibility, more stable.	http://www.schneider-electric.fr/sites/france/fr/produits-services/formations/formations-energy-university.page-05.04.2016
Energy power lab e-learning platform	PHP 5.3.29 Apache	Security, flexibility.	http://www.energypowerlab.com/31-renewabletraining.htm-05.04.2016
Solar energy international online courses	CMS WordPress 4.3.1 PHP 5.4.43	Content Management System (CMS) made simple, easy update, most used, easy customization.	http://www.solarenergy.org/online/-05.04.2016
TERI university	CMS Joomla PHP 5.3.3 Apache 2.2.15	CMS made simple, easy update.	http://www.teriuniversity.ac.in/index.php?option=com_program&task=program&sno=20-05.04.2016

5 Proposed E-learning Energy Platform

Morocco has known a great development in the field of renewable energy especially in solar and wind energy. With this strategy aiming to improve green education, E-learning platform will be a suitable solution for renewable energy education programs in Morocco. In this work, we will propose an E-learning solution that will be implemented and documented in our future works. Until now, the courses of the platform are developed in collaboration with experts in the field of renewable energy.

5.1 The Goals of the Proposed Platform

- Self-study that allows the student to progress according to his own capacity and evaluate his progress at any time. It puts at disposal the course material and also practical activities.
- The system allows the interaction between the course members so that they can share information and discuss the proposed topics. Also, a part of knowledge will be constructed by the group.

- Students are supported and guided by the tutor during the learning and teaching process.
- The student becomes an active element in the teaching and learning process.
- This model consists of how students learn and not how teachers teach.
- The targeted educational levels are at university level.
- The training must help students to understand green energy concepts.
- The students must be responsible in the learning process, especially in time management.

5.2 *Courses Organization*

The list of topics will be developed by specialists in the green energy technologies. Each of topics is presented with a didactical manner to attract students' attention during the learning process. The common structure of the course is: introduction, contents, case studies, extra sections and bibliography.

Indeed, the topic presented is based on different learning activities (forums, videos, presentations, animations, audio, simulations, e-books etc). During the learning process, some practical examples together with some exercises will be available to help the student well understand the topic and also to make him/her familiar with green energy concept. At the end of each course, students are evaluated through tests to measure their knowledge and study pace. Moreover, the tutors will guide the students via e-mails, forums and conversation (chat, interactive talks or, video). The platform provides different units: communication unit (forums, discussion groups, e-mails etc), information services (dictionaries, e-books, e-journals, important web sites etc) and assessment unit (tests, exercises, auto-evaluations, monitoring tools etc). Thus, several tools allow content management of platform to exist, but the most adapted tool to our platform is the LMS that has huge features.

5.3 *Selected Platform*

There is a diversity of various open source Learning Management Systems (LMS), such as ATutor, Moodle, Dokeos, Ganesha, Eliademy, Claroline, Sakai, Chamilo, etc. LMS is defined in [10] as a system used to ease the process of communication between students and instructors. For this purpose, a detailed selection was made among different open-source platforms currently used in large universities and institutions structures to pick and choose the best suited tool to our training environment and our vision. As a result, the choice was made on MOODLE (Modular Object-Oriented Dynamic Learning Environment). Several definitions of MOODLE are presented in literature, [11] present MOODLE as a technology platform which

Table 2 Essential advantages of moodle

Level advantages	Advantages	Category
1st-level	<ul style="list-style-type: none"> • Open source software that any educational organization can acquire it for free, without worrying neither about the purchase costs nor about rights to use license 	Financial
2nd-level	<ul style="list-style-type: none"> • Offers more interactivity between learner and teacher • Works by the social-constructivist approach • Proposes planned activities to allow learners to create content, such as (forums, wikis, glossaries, messaging, etc.) to construct their own knowledge 	Pedagogical
3rd-level	<ul style="list-style-type: none"> • Offers more usability to creator or designer of online course • Provides opportunities for unlimited configurations and learning becomes more personalized 	Creation process
	<ul style="list-style-type: none"> • Application is constantly revised and updated for free by hundreds of programmers 	

offers educational institutions and training organizations and gives the capacity and the capability to create courses online and E-learning websites. Thus, it allows the organization offering online courses to arrange content manage learning, facilitating interactivity between learner and teacher and assess the learner.

This technology is easily integrated into the technological infrastructure of the university. Furthermore, it is most adapted to the interests of programmers and operators of education (learners, teachers and administrators) because it presents some benefits that other learning software do not offer. The following table shows essential advantages collected of Moodle (Table 2).

6 Conclusion

In this paper, we have reported E-learning platforms as an attractive and new method for teaching and learning especially in the case of energy education since Morocco is developing its renewable energy infrastructure.

E-learning platforms such as RegEn-M, Energy University and Power Energy Lab E-learning and others are presented and a qualitative comparison between platforms was made. Generally, they use either dynamic websites manually developed or they use CMS. They provide a variety of teaching materials, although, there exist other more effective and adapted ways to learn in a distance-learning environment.

For developing countries such Morocco, this kind of solution has clearly shown its importance as it offers a huge number of tools to enrich and empower the competencies of engineers and researchers during their curriculum to fulfill the requirements of green energy industry. This paper also highlights our vision about the E-learning platform that we will implement, based on the studies concerning

renewable energy in Morocco. In this context, a detailed selection was made among different open-source platforms to choose the best suited to our training environment and our vision. As a result, the choice was made on MOODLE platform.

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