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PROCEEDINGS

The Program of the 12th International Symposium on Renewable Energy Education includes an Opening Address, 8 Keynote presentations, 15 oral presentations, and 5 poster presentations; in all 29 presentations, numbered 1-29. The Book of Abstracts lists the presentations alphabetically after the first author’s family name.

Out of these, 18 are written as (about) 6-page papers, which are collected as pdf files on a USB stick that accompanies the Book of Abstracts. The papers are separate files, numbered as the Abstracts, and named after the first author’s name (if two authors “name and name”, if more authors “name et al”).

Strömstad 12 June
Lars Broman, ISREE 2017 Chair

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Community-Based Renewable Energy Education and Training for Sustainable Development

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Abstract

The paper will examine the assertion that development should not only be seen as an economic process of wealth accumulation, but rather as a socio-political process of empowerment. This realization has major implications for how NGOs approach development.

The paper also examines how technology, both a blessing and curse, is critical for individuals and communities accessing and managing resources. Equitable distribution of the productive gains, environmental impacts, debt burdens, health consequences and impacts on the social and cultural fabric of a community should be discussed openly and taken into consideration.

The paper reports on the field experience gained from the Basaisa Village project (started in 1974) and the New Basaisa project (started in 1992). The paper discusses some of the practical and ethical challenges faced by community members and field workers in their efforts to develop or introduce new technologies in the two communities to enhance human well-being. Important concepts, strategies, and approaches that work in the field are presented and discussed. The paper recommends some successful participatory approaches to community-based education and training for sustainable development.

Key words: Renewable Energy – Public Dialogue – Rural Community – Community-Based Education and Training - Sustainable Development

1. Introduction

Sustainable community development/solutions can't be pursued as a sectarian initiative. In fact, the special importance of the effort outlined in this paper as a program of action lies in its integrated/interdisciplinary approach, its attempt to combine renewable energy technology promotion and youth employment, construction of new settlement, poverty eradication, social integration and equality into coordinated and participatory plan of action. The paper reports on the progress of two unique grassroots initiatives: one that started 1974 in a small village at the heart of the Nile-Delta called Basaisa (www.google.com/BasaisaVillage) and one that started 1992 in a new desert community called New Basaisa (www.google.com/NewBasaisa) in South Sinai, Egypt. It describes the renewable energy technologies and public education methodologies used and the approaches that work as well as the problems facing its implementation and the achievements to date. Small photovoltaic power units were used as multifunction units. Producing electricity for training and education, some time for TV, some time for the Friday pray in the Mosque, and other times for production activities in small workshops for income-generating activities. Knowing that one source of energy can't satisfy all needs in a community, other technologies were used like biogas, wind and Solar heating.
The paper discusses the development of the two Basaisa communities to-date as an educational process. The paper also presents a vision of integrated approach to planned internal migration for human settlements as new productive eco-desert communities outside the overcrowded narrow Nile-Valley and Nile-Delta.

As Egypt's document for the 21st Century states "to get out of the old valley to the desert is not merely an option to select from available alternatives, but rather a matter of life not only for the present generation, but also for the future generation". Crowdedness leads to an overall gradual deterioration in urban utilities and loss of civilized image. It renders futile any efforts exerted in cleaning and beautifying cities and controlling pollution. Besides, it had the effect of turning behavior from a tolerant to an aggressive attitude. The smallest community in developing areas is a complex tapestry of values, some cultural, some economic, some political, some religious, but all with a community history and tradition. The problems in a given community are so interlinked and so complex that can never be fully understood or solved by simplistic perceptions, technical or economic, or by one stakeholder. The transformation process (Development) of a community can only be positive if the direct beneficiaries, local people, catalysts, and the leaders of that community are actively involved in the process and also continuously in possession of information, innovative ideas and approaches that work, and skills that are needed to sustain environmentally sound and equitable development process.

1.1 Energy and Community Development

The relationship between energy and development is a dynamic one in which the amount, type, and trajectory of economic growth or development are mutually dependent variables on the quantity, kind, and price of energy available. There is a growing consensus that successful development requires a firm agricultural foundation, and that the basic quality of life must be improved for and with the participation of the poor people living in the countryside, who are the majority. If this can be done (no one suggests that it can be done either easily or quickly). Then the rural poor may have reason and ability to reduce their birth rates, may increase their food production as well as consumption, and may no longer be forced to flee to already overcrowded towns and cities. Carefully and persistently pursued, a fully integrated rural development program could provide a sound basis for the manufacturing and service sectors of a self-reliant and thriving national economy. Increasing energy supply and efficiency of energy use will be very important aspects of any such comprehensive rural development strategy. Energy development strategies directed towards meeting the needs of the poor majority are bound to fail if no effort is made at the same time on the development of the economic and technological capabilities of the rural poor and the socio-cultural and political structures of their community.

1.2 The Basaisa Village

Basaisa, like nearly 30,000 other satellite village in Egypt, is a small rural community. The life of its inhabitants is dependent and organized around the cycle of agriculture in which men, women, and children all have a vital role to play in the production and processing of crops and residues that provide their livelihood. Basaisa village has a total population of 320 grouped in 45 households, forming 62 families. The village lies in the heart of the Nile-Delta, 100 kilometers northeast of Cairo and 15 kilometers northwest of Zagazig, which is the capital of Al-Sharikiya Governorate of Egypt.

Many houses are still made of adobe bricks and roofed which dried cotton, rice, and maize residues, which serve mainly as fuel for cooking and bread baking. There is no formal service in the village, and the nearest primary school or health unit is about three kilometers away.
Basaisa land holding consists of about 80 feddans (one feddan = 1.038 acres = 4200 m²), all of which are cultivated and cared for by the village inhabitants. Most of the land holdings are divided up into small parcels varying in size from three-four carats (one feddan = 24 carat), to two-three feddans. Although only two families own up to eight feddans, these are often scattered and broken up as a result of inheritance patterns. The average (cash) income is L.E. 1800 ($ 330 US) for person per year, which is very low. The village inhabitants have had no real opportunity to participate in the process of development locally, regionally, or nationally development that is allegedly geared to their needs and conditions. Their social and economic conditions allow them little status, information, or power. Their economic assets are often too small to make them credit-worthy by conventional standard, to permit them to take risks with new technologies, or to market their meager surpluses at reasonable prices.

The Basaisa Integrated Field project was originally co-sponsored by the New Mexico Solar Energy Institute (NMSEI) and the American University in Cairo (AUC) and was funded by the US National Science Foundation as well as other organizations. The African development foundation (ADF) in Washington, D.C., awarded a grant in 1985 to complete construction of the Integrated Rural Technology Center for Training and production (IRTECTAP) and to support other efforts of the project.

1.3 The New Basaisa Community

New Basaisa is a desert community constructed at Ras Sudr, South of Sinai Governorate, Egypt. The project is a grass-roots initiative aiming at the construction and development of a new productive settlement in the Sinai desert using innovative production and service ideas and renewable energy resources and based on participatory actions. It is a living model for organized internal migration and desert distribution of the population and for the construction and development of eco-desert communities. This village presents a model of development of new communities with emphasis on the use of renewable energies, the participation of the local people, and the role of the newly established non-governmental organizations in such a unique grassroots Project. Today, New Basaisa covers 750 feddans communally owned by about 100 members, all literate. Each young person was given five feddans to cultivate at his own pace, and membership in the cooperative was also opened to interested youth from outside Basaisa. Investors not wishing to move there were also accepted, provided they employed another young person to cultivate the land. The maximum allocation for individual investors was set at 20 feddans. The inclusion of larger investors to the cooperative, all bound by the rules agreed upon by the general membership, was instrumental in providing the cash infusions needed for the project to progress at a steady pace.
2. **Project Methodology**

Our primary strategy was based on the concept of direct dialogues as the starting point for the innovative process, a process that was conceived and defined not only the work to spread an innovation, but also the identification and awareness of the underlying problem to be solved as seen in the perspective of the periphery. Furthermore, there had to be the organization and mobilization of those people who suffered most from the problem in order for them to participate in doing something innovative about it. Here, innovation was the end, rather than the beginning of the process. The innovative process was, thus, seen as involving both an increasing consciousness of grassroots problems and the innovative action to solve those problems at the local level. Collective and individual discussions were held not only in the village with the inhabitants of Basaisa and its neighboring communities, but also at AUC with project volunteers and staff. Whenever needed and appropriate, we made use of basic anthropological fieldwork methods: census taking, genealogical charts, participant-observations, points of view, surveys, literature reviews, field surveys, seminars, field visits, and use of external consultants where necessary.

2.1 **Introduction of New Technologies**

The introduction of a new technology depends primarily on an education process for its success and for its widespread adoption. Our work has shown that only when people are taught and have experienced a new technology’s advantages. Are they willing to work or spend the additional money for its acquisition inhabitants of the village community must be involved at different levels in all stages. The technology of briquetting was introduced to the villagers of Basaisa in stage, with the project investigators and technical staff responsible for the regular communication of information.

3. **Community-Based Education and Training Practices**

Community-based education or Community learning & development, also known as Public education, refers to programs to promote learning and social development work with individuals and groups in their communities using a range of formal and informal methods. A common defining feature is that programmes and activities are developed in dialogue with communities and participants. The purpose of community learning and development is to develop the capacity of individuals and groups of all ages through their actions, the capacity of communities, to improve their quality of life. Central to this is their ability to participate in democratic processes. Community education encompasses all those occupations and
approaches that are concerned with running education and development programmes within local communities, rather than within educational institutions such as schools, colleges and universities. The latter is known as the formal education system, whereas community education is sometimes called informal education. It has long been critical of aspects of the formal education system for failing large sections of the population in all countries and had a particular concern for taking learning and development opportunities out to socio-economically disadvantaged individuals and poorer areas, although it can be provided more broadly.

3.1 Public Education and Training as key element in sustainable community development

Public awareness and understanding is the fuel for change and an indispensable effort to suppur change towards sustainable development. Problems of vested interests, the difficulties of communicating science, the complexity of the issues, and the tendency of the media to focus an extreme positions and controversies are considered and discussed. It is suggested that the most effective communication strategy for building awareness and understanding is to focus on local problems which the public experiences in everyday life. It is also suggested that Education must emphasizes the importance of the concept of lifelong learning (continuing education) in a rapidly changing world, as well as the need to give high priority to basic education in the developing areas, there is a need for a national educational reforms and to develop interdisciplinary studies and programs that link Research – Education – training and community services – sustainable development. Education must promote a sense of both local and global responsibility. Community educators have over many years developed a range of skills and approaches for working within local communities and in particular with disadvantaged people. These include less formal educational methods, community organizing and group work skills. Since the nineteen sixties and seventies through the various anti poverty programs in both developed and developing countries, This was for many years based at the Community Education Development Centre based in Coventry UK. ICEA and CEDC have now closed. This does not however mean that there is not a continuation of this practice around the world, far from it. But that outreach community education work now adopts many
job titles. In the UK the main trades union representing people working in this field is the Community and Youth Workers Union, which is part of the wider UNITE union.

- **Achievement through learning for adults**

  Raising standards of achievement in learning for adults through community-based lifelong learning opportunities incorporating the core skills of literacy, numeracy, communications, working with others, problem solving and information communications technology (ICT).

- **Achievement through learning for youth**

  Engaging with young people to facilitate their personal, social and educational development and enable them to gain a voice, influence and place in society.

- **Achievement through building community capacity**

  Building community capacity and influence by enabling people to develop the confidence, understanding and skills required to influence decision making and service delivery.

  The shortest way to achieve our goals was a democratic and free opened dialogue between all of community members. The main principle in community development is a well educated and trained citizen has life and technological skills enable him/her to participate in community development.

  **4. Results and Discussion**

  The smallest community in developing areas is a complex tapestry of values, some cultural, some economic, some political, some religious, but all with a community history and tradition. The problems in a given community are so interlinked and so complex that can never be fully understood or solved by simplistic perceptions, technical or economic, or by one stakeholder.

  The transformation process (Development) of a community can only be positive if the direct beneficiaries, local people, catalysts, and the leaders of that community are actively involved in the process and also continuously in possession of information, innovative ideas and approaches that work, and skills that are needed to sustain environmentally sound and equitable development process.

  In its simple definition development is a process of change. The one responsible for such change is the one who knows – posses knowledge. The knowledge is produced in research
centers and universities and is transferred from where it is produced to where it is needed in developing communities through education.

A pre-requisite for sustainable community development is a well brought up and well educated citizen, who possess technical and life skills to make him/her active participant in the development process and to empower him/her to protect the environment and the national heritage. The proposed solutions, based on unique field experiences in research and public education, will help solve some of the current energy, education, unemployment, waste, sanitation, and health issues facing local communities in Egypt.

The proposed solutions, based on such two unique field experiences, will help solve some of the current energy, education, waste, sanitation and health issues faced in small villages and desert communities in Egypt and elsewhere.

Acknowledgements
Thanks to Basaisa people and all participants; Special thanks to AUC and all volunteers.

References
Higher Education and Education of the Public in Energy Conversion in Austria and Egypt
Photovoltaics and Electrochemical Storage

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Abstract
Higher education on the one hand and education of the public on the other hand play an essential role in the development of any community. The implementation and maintenance of renewable energy systems such as the conversion of sunlight into electricity and its planned consumption: photovoltaics and its electrochemical storage are essential factor of the development process.

This paper presents examples of lab courses for higher education for photovoltaics as well as electrochemical storage held at the degree program ‘eco-energy engineering’ at the Upper Austrian University of Applied Sciences in Austria over the last 3 years.

Key words: Solar Cells, Batteries, Perovskite solar cells, Lead-Acid Battery, Li-ion Battery, Zinc-Air Battery, Fuel Cells, Lab Course

1. Photovoltaics

The worldwide renewable electrical energy production was 23.7% by the end of 2015, while photovoltaics alone had a share of 1.2%1. Currently about 90% of solar cells are based on silicon that require cleanroom facilities in production and are therefore difficult to produce in a teaching lab. Perovskite solar cells on the other hand are a recently emerged technology that showed an impressive performance in efficiency over the last years2 and have recently reached an efficiency of 22.1%3. These solar cells although containing toxic materials such as lead can be produced by using relatively simple wet chemistry, with temperatures maxing at 500 °C.

Here we present the results of student group projects at the Upper Austrian University of Applied Sciences – Austria’s largest and most research oriented University of Applied Sciences (www.fh-wels.at) - done in the degree program eco-energy engineering to build and characterise a fully working thin organic inorganic perovskite solar cell in basic educational chemistry labs at low costs4.

1.1 Perovskite Solar Cells

Similar to dye-sensitized solar cells5, the perovskite material is coated onto a charge-conducting mesoporous scaffold such as TiO2 as light-absorber. The photo generated electrons are transferred from the perovskite to the electron conducting TiO2 through which they are transported to the electrode and extracted to the circuit. At the other end the holes are transported by the copper thiocyanate layer. Figure 1a shows the scheme used in this project. The term perovskite describes the crystal structure of a calcium titanium oxide – mineral CaTiO3 (ABX3 structure). The material used in this work is CH3NH3PbI3 with methyl-
ammonium iodine (MAI, CH$_3$NH$_3$I) in A position, lead (Pb) in B and iodide (I) in X position. Perovskite material is sensitive to water, which makes it highly prone to rapid degradation in moist environments and solar cells decompose after a few weeks when left on air.

The perovskite is applied in a one step method as described by Padwardhan et al. in$^6$ and a modified two-step method. The company Ossila sells ready made precursor solutions. Furthermore, the following materials were used for the production of the solar cells: FTO (fluorine doped tin oxide by ISE Fraunhofer) - glass as substrate, titanium dioxide (TiO$_2$) was utilized as scaffold and electron transport material, copper thiocyanate (CuSCN) as hole transporting material and silver paste (Ag) or graphite (C) as back conductor. Figure 1b shows the scanning electron micrograph of a cross section of a perovskite solar cell.

In one part of the project a spin coater shown in Figure 2a was built in house. The DC-motor is easily cable-connected with a DC voltage source. The advantage of this motor is that it provides a direct correlation between the electric supply voltage and the rotation speed. The rotational speed was determined in a range of 500 rpm (e.g. 2500 – 3000 rpm). This design should make it possible to adjust the spin coater easy to the required rotation speed with an accuracy of at least +/- 50 rpm and produce uniform layers on the substrate. Perovskite solar cells as shown in Figure 2b have an open circuit voltage ($V_{OC}$) of about 400mV and a short circuit current ($I_{SC}$) of up to 1mA and can be characterised with a suitable light source and a volt/ampere meter$^7$. More information of the production can be found via a short video done during the project$^8$. 

Figure 1 a) Schematic of a perovskite solar cell. b) Scanning electron micrograph of a perovskite solar cell cross section. The SE micrograph was done with a Schottky FE-Kathodensystem field emitter (TESCAN MIRA3 LMH FE-REM with Oxford AZtec Energy EDX for element analysis). The scale bar is 1µm.

Figure 2 a) In house built spin-coater b) Characterisation of $V_{OC}$ and $I_{SC}$ of a perovskite solar cell under radiation.

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2. Electrochemical Storage

The fundamental comprehension of electrochemical storage technologies such as batteries and fuel cells play an essential role in the implementation of renewable energy systems for engineering students. Here we present briefly lab course experiences and exercises for widely used storage systems such as lead-acid and zinc-air batteries.

2.1 Lead-Acid Battery

Lead acid batteries represent the largest sector in worldwide battery industry. They are heavily used as portable power sources for vehicles as well as stationary applications ranging from small emergency supplies to load levelling systems. The lead acid battery is the only system where the negative and positive electrode consist of the same material: lead (Pb) in its metallic Pb and oxidic form PbO2.

Electrochemical cell: \[ \text{Pb(s)} | \text{PbSO}_4(s) | \text{H}_2\text{SO}_4(aq) | \text{PbSO}_4(s) | \text{PbO}_2(s) | \text{Pb(s)} \]

Positive electrode: \[ \text{Pb} + \text{H}_2\text{SO}_4 \rightarrow \text{PbSO}_4 + 2\text{e}^- + 2\text{H}^+ \]

Negative electrode: \[ 2\text{H}^+ + 2\text{e}^- + \text{PbO}_2 + \text{H}_2\text{SO}_4 \rightarrow \text{PbSO}_4 + 2\text{H}_2\text{O} \]

A schema of the reactions taking place during discharge is given in Figure 3a. The negative electrode material Pb dissolves to Pb\(^{2+}\) in the electrolyte is an aqueous solution of sulfuric acid. The positive electrode material PbO\(_2\) is dissolved and reduced to PbSO\(_4\). Both reactions end in solid PbSO\(_4\), which is slightly soluble in sulfuric acid and form water. The water molecules are formed of oxygen in PbO\(_2\) and H\(^+\)-ions of the sulfuric acid. A lead acid cell can be easily built in a lab by providing 5% sulphuric acid and two bars of lead separated by a filter paper as shown in Figure 3b. To charge the system a voltage of 3V is applied (the current should be lower than 50mA during charging). By connecting a resistance of 33 Ohm a curve of discharge can be measured and the stored energy calculated by the students.

![Figure 3 a) Chemical reactions during discharge of a lead acid battery. b) lead-acid system in a chemical lab.](image)

2.2 Zinc-Air Battery

Batteries using zinc as a negative electrode are widely used for small-scale batteries (zinc-carbon, alkaline batteries, silveroxide-zinc, mercury-oxide zinc, zinc-air, etc.). Zinc is a light metal, which results in a high specific charge (almost 200% more than lead) and has a very low potential. The material is cheap and abundant. A major advantage is the high specific energy of 200 Whkg\(^{-1}\) since the oxygen is provided by the systems environment.
Electrochemical cell: \[ \text{Zn(s)} | \text{KOH(aq)} | \text{C(s)} , \text{O}_2(g) \]

Cell reaction: \[ \text{Zn} + \frac{1}{2} \text{O}_2 + \text{H}_2\text{O} \rightarrow \text{Zn(OH)}_2 \]

During discharge of a zinc-air battery in an alkaline electrolyte (6M KOH) zinc oxidizes to zinc oxide or hydroxide as shown in Figure 4a. A battery can be easily built in a lab using a zinc rod as positive electrode, a filter paper as separator and a carbon rod (providing the oxygen form air) as negative electrode. Figure 4b shows students able to measure the voltage and short circuit current and light a suitable LED.

2.3 Li-ion Battery

Lithium-ion batteries dominate the market of for portable devices such as mobile phones or laptops as well as traction batteries in electric vehicles. Lithium is with a density of 0.534 g/cm$^3$ at 20°C the lightest of all metals. Furthermore, the potential of $E^0 = -3.045$V enables the production of batteries with high power and energy density. However, lithium reacts heavily with water, therefore, the electrolyte has to be non-aqueous.

During discharge the negative (graphite) electrode acts as a source and the positive LiMO$_2$ (M= Co, Mn, …) as a sink for Li-ions as shown in Figure 5a. Figure 5b shows a Li-ion battery that can be built and characterised in a lab by using two graphite rods (Dual-carbon cell) using lithium perchlorate dissolved in propylene carbonate or propylene carbonate/dimethyl carbonate solution in a beaker covered in paraffin oil to avoid contact with moisture. The battery can be charged by applying a voltage of 6V for about 6 min. By applying a suitable load (such as a diode) the voltage characteristics may be measured. Furthermore, the impact of Li-ion intercalation in graphite can be observed macroscopically as depicted in Figure 5c.

Electrochemical cell: \[ \text{LiC}_6(s) | \text{non-aqueous Li}^+ \text{ electrolyte} | \text{LiMO}_2 \]

Positive electrode: \[ \text{Li}_{1-x}\text{MO}_2 + \text{Li}_x\text{C}_n \rightarrow \text{LiMO}_2 + \text{C}_n \]

Negative electrode: \[ \text{Li}^+ + \text{Li}_{1-x}\text{MO}_2 + e^- \rightarrow \text{LiMO}_2 \]
3. Photovoltaic Island Systems

This part of the paper presents field experience in educating the public on the use and maintenance of photovoltaic island systems with a lead acid storage system to the inhabitants of the New Basaisa 8km north of Ras Sudr, an eco-village which started in 1992 in South Sinai, Egypt. This desert development project utilizes natural resources sustainably to create eco-friendly communities in rural areas.

3.1 Photovoltaic Island Systems in New Bassaisa

Sulfuric acid is not just an electrolyte but plays an important role in the reaction of a lead-acid battery as seen in Figure 3a. During discharge the concentration of PbSO₄ through reaction with the sulfuric acid increases. The acid has a higher density than water, a decrease of the acid concentration results in a decrease of the electrolytes density. Therefore, the electrolytes
density gives information about the charge state of the battery, which can be measured using a hydrometer. A fully charged battery has a density of 1.28 kg/l, a half-charged battery 1.20 kg/l and a fully discharged battery 1.10 kg/l (data provided by Varta).

The $V_{OC}$ depends on the sulphuric acid and water activity and temperature. Lead sulphate is a very poor electrical conductor and its deposition in a dense fine gained form can shield and passivate both electrodes, so that the practical capacity of a cell can become decreased.

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References

7. [http://www.pveducation.org](http://www.pveducation.org)
The Lost Innocence of Renewables –
How to Teach Renewable Energy Technology
Without Neglecting Undesirable Side Effects

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Abstract – When after the oil crises in the seventies and eighties of the last century and especially after the publication of Limits to Growth of the Club of Rome, the public focus shifted to a future without fossil fuel. Renewables became a quasi ‘religious’ promise for a better world. After a period dominated by enthusiastic pioneers in universities and newly found start-up companies, industrialization and commercialization of what had been ‘small and beautiful’ grew big. Dissatisfied with side effects of the implementation of big-scale technology, citizens started movements against wind farm projects and nature preservation organizations were fighting renewable energy projects. Biodiversity issues as well concern about the well being of rural populations emerged. With increased technical sophistication and the concentration process in RE industry, public opinion became more and more critical.

Enthusiasm of students in RET study programs about their selected subject thus needs counterbalance by educating them on the side effects of uncritical and mainly profit-oriented implementation of RETs.

Key Words: Side Effects, Renewables, Education, Sustainability, Barriers

1. Introduction

The oil crisis of 1973 and the study The Limits to Growth (see [1]) fostered an ever increasing interest in Renewable Energy Technologies. It became obvious that the domination of fossil fuels would be a short period in human history and had no chance to last for long [2]. There was also in increased interest in decentralized, humane ways of production (Schumacher [17]).

Nevertheless it was well understood that one reason for underdevelopment in all its forms (malnutrition, lack of education, unemployment etc.) was the unavailability of sustainable energy supply in many regions of the world (See e.g. [3]).

The development of Renewable Energy Technologies (RET) created jobs and a demand of qualified personnel at all levels. Renewable Energy Education became a topic in the late Eighties of the last century and concentrated on the scientific, technical and economic questions that arose from the introduction of Energy conversion and storage
systems in the field of Biomass, Solar, Wind and Hydropower. Fostered by subsidies or other forms of legislation, but more and more by the spreading of knowledge of the potential of and falling prices of RETs market mechanisms Renewables gained increased “popularity”.

But was once had begun as “small and beautiful”, as “alternative energy” melted into the mainstream of energy business operations, lost public sympathies by those who had to pay higher electricity rates or live near a wind farm - without having any advantage of the changed personal environment.

It ist obvious that quite a few of the conflicts between project developers and local citizens that hit the headlines could have been avoided by foresight, planning with participation of locals and a certain degree of consciousness of the side effects of project implementation.

The replacement of nuclear of fossil power by renewable electricity e.g. in Germany demands a restructuring of the power grid. New high voltage lines have to be planned – and their construction affects the nature as well as habitat of many people in densely populated countries. Therefore the once overall positive attitude of the public with respect to the shift to renewables (“Energiewende”) became threatened. The way how governmental bodies and power line companies “push through” what they think to be necessary, feeds “concerned” citizens’ opposition against bigger renewable energy projects. In many situations organizations dedicated for the protection of the natural environment, who in their program support renewable energy, oppose RET projects on local level.

So it seems to be obvious that education and professional training on all levels and in all fields of renewables, requires a keen view on the problems and side effects of the implementation of RET projects.

2. “Classical” Barriers for RETs

Among the pioneers of RETs it was often understood that barriers to the wider implementation of Renewables were ignorance, commercial interests of power utilities, political “influence” and the “not-invented-here” syndrome (for a definition see [11]) – as Benjamin K. Sovacool expressed, “some of the most surreptitious, yet powerful, impediments facing renewable energy and energy efficiency (...) are more about culture and institutions than engineering and science” [9, 10].

In 2006 by UK economist Nicholas Stern pointed out “National grids are usually tailored towards the operation of centralized power plants and thus favor their performance. Technologies that do not easily fit into these networks may struggle to enter the market, even if the technology itself is commercially viable. This applies to distributed generation as most grids are not suited to receive electricity from many small sources. Large-scale renewables may also encounter problems if they are sited in areas far from existing grids”. [12]

RE study programs have to cover this kind of barriers of course.
3. “New” Barriers

Especially Wind Energy projects face well organized resistance – the complaints touch all possible negative aspects of wind farms and their operation – see e.g. the web site of the European Platform Against Windfarms (EPAW) [16]. Engineers and project developers/planners have to answer questions about medical, psychological and bird migration safety questions, before the authorities or the public will accept the project. Sometimes the efforts for this part of preparation of a large-scale RE project extend the respective work for wind potential evaluation and farm layout etc.

In Germany efficient employment of renewable electricity has been slowed by lack of an accompanying investment in power infrastructure to bring the power to market. It is believed 8,000 km of power lines must be built or upgraded [13] So the increased costs of the “Energiewende” have been passed on to consumers, who have had rising electricity bills, which became a major political issue. New power lines are difficult to implement and construct in a densely populated country, especially as local people fight for “their” natural environment with extreme sturdiness. The financing scheme for new power lines (guaranteed revenues for investing power-line companies) creates suspicion – the public assumes that not renewable energy feed-in but energy-trade profits are the ultimate motivation.

This leads to embittered fights of grassroot initiatives against new power line projects (see e.g. [14, 15]) and it is completely open, if this will slow down German “Energiewende” substantially.

It seems to be obvious that curricula for Renewable Energy study have to touch the subject of “new” barriers and obstacles.
4. What To Do -- Remedies

Students of Renewable Energy technologies have in general a motivation that is either based on technical/scientific interest and/or ecological insights. Recently, career perspectives in a growing sector of renewable industries might also be a welcome motivation. Therefore in the beginning these students have difficulties to imagine how other people could not be “pro renewable”. It is vital for the long-term success of technologies, of projects and then whole industries to be sensible for the view of “ordinary citizens” with regard to side effects of RETs and their implementation.

In order to prevent disillusionment and failure in the career after RE studies, students should, apart from a solid theoretical and practical education of the fundamentals and the applications of RETs, be involved in classes covering social and economic, political and environmental aspects of their future work-life.

Study units qualified for this purpose are:

**Country_Reports** When researching the energy situation of a country and investigating the overall potential, coverage and perspectives of RETs, students should be guided to included barriers, problems and failed RE projects as well. They might find, that it is a long, hard pathway for the integration of Renewables into a National Energy Scenarios as well as into the national grid. And they will understand that consumers dont need kilowatthours but energy services like clean water, heating or cooling and a reliable electricity supply for their home. The effort’s outcome has to be a presentation in class and a substantially balanced written report.

**Project_Reviews** Students can learn how energy related projects are reviewed and what kind of obstacles, failures and and unexpected side effects influence the end result. They might start think over how they might evaluate a project and what kind of methodology they would need.
Case_Studies In a case study project a group students develop, based on what they have learned about the fundamentals of RE, a detailed project for a specific energy supply system. If guided well, an interaction with clients, beneficiaries and if applicable donors/investors ist mandatory. Of course all kinds of laws and regulations that apply have to be regraded as well.

Site_Visits/Study_Tours On-site visits to wind farms, biomass power stations, “energy villages”, manufacturers, planning offices etc and the evaluation and discussion of these tours widen the horizon of students in a valuable and irreplaceable way.

Thesis_Projects Students who do their thesis projects in co-operation with an external company or institution and work on an specific applied topic, will find out more about the “realities” of their future work environment and give them insights they will need to be successful in their career planning.

Energy_Economics classes give students deeper insight into market mechanisms and how energy prices and external costs will influence technical decisions. The issue of Sustainability and ist link to economics has to be covered. (See e.g. [20])

5. Outlook
As the media presence of disputes about RET projects increases and especially after the noise made by organized and well funded climate change skeptics will make RET students very conscious with respect to the links of their subject to social, environmental and economic issues. They will ask for classes and units that fulfil their demand for information and competence in the areas slightly beyond the purely scientific and technical field. The wishes of the students should be met by the curricula.

Acknowledgements
I want to express my thanks to my former colleagues at the Postgraduate Programme Renewable Energy (http://www.ppre.de), especially Hans Holtorf, Evelyn Brudler, Tanja Behrendt, Eduard Knagge, Andreas Günther, Robin Knecht and Michael Golba.

References


[14] *Bundesverband der Bürgerinitiativen gegen SuedLink* (citizens’ action committee against power line SuedLink)http://bundesverband-gegen-suedlink.de/


[16] European Platform Against Windfarms
http://www.epaw.org/about_us.php?lang=en


[18] https://www.uni-oldenburg.de/fileadmin/_processed/6/2/csm_excursion-Juehnde_Village_e3792804b7.jpg

[19] https://sustainabilityworkshop.wordpress.com/

European Solar Engineering School ESES, Master Program at Dalarna University

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Abstract
The Master program in solar energy engineering ESES at Dalarna University, Borlänge, Sweden, is now into its 17th year. From the beginning, it was a 1-year “magister program”, but since 2015, students can choose to study for one or two years. Since the beginning, 220 students from almost 100 countries have been examined.

Key words: ESES, solar energy engineering, master program

1. ESES Background, Pre-History, and Start

Solar Energy Research Center SERC started at Högskolan Falun Borlänge – now Dalarna University – in November 1984 as the first research center at any Swedish University College. Gradually, it has grown from a minor institution, not always appreciated by the rest of the University, into Sweden’s leading research center in its field.

European Solar Engineering School ESES was originally intended to be established on the Italian island of Capri, but began as a master level program at Dalarna University at the beginning of the fall semester 1999. ESES attracts students from all over the world and has today a reputation as one of the world’s best educations in its field. Lars Broman’s role was to initiate SERC and ESES and being instrumental in their respective first years of development, while their continued growth has depended highly on his former colleagues, still active at Dalarna University (Broman 1994, 2014). Now ESES is co-ordinated by Frank Fiedler and Desirée Kroner.

The early beginning of ESES depended a lot on the intensive discussions and planning of a working group consisting of Lars Broman, Lars Kristoferson, Ulf Kusoffsksy and Bengt Hidemark from Sweden, Konrad Blum from Germany and Vanni Garofoli from Italy (Broman et al 1998).
2. ESES Development During 16 Years

The first year, around 10 students attended the ESES program. Then, yearly, between 25 and 45 students have followed the 1-yr and lately the 2-yr Master program. In addition, some 10-16 ERASMUS scholarship students have studied parts of the program. Since the beginning in 1999, over 400 students from some 100 countries from all continents (except Antarctica) have studied parts of the program or the entire program.

At the beginning, ESES had to rely largely on guest lecturers; among them Prof. H.P. Garg from India, Prof. Bengt Hidemark, Dr. Heimo Zinko, and several others. The original curriculum included a 7.5cr course based on the classical book Solar Engineering of Thermal Processes (Duffie and Beckman 2005 – now 4th edition). Another other basic course was in photovoltaics, based on Martin Greens three books. Following courses dealt with solar energy economy, solar energy in developing countries, and solar energy in buildings. It should be noted that Prof. Garg after two years lecturing in ESES required a younger IIT professor Tara Kandpal, who has lectured yearly in Borlänge since.

Below, see the latest group of lecturers and teachers at ESES:

![ESES 2016/17 Staff Image]

Figure 1. ESES 2016/17 Staff.
3. ESES Today

Presently (2017), 25 students are taking the 2-year Master program, while eight students read the one-year master level program.

Duffie-Beckman (2005) is still the basic of solar thermal studies, while Green has been replaced by the German Planning and Installing Photovoltaic Systems (2015)

Below are shown the curricula for the present ESES programs:

<table>
<thead>
<tr>
<th><strong>Autumn 1st semester</strong></th>
<th><strong>Spring 2nd semester</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>EG3015 Solar Radiation and Solar Geometry, 5 cr</td>
<td>EG3009 Design of Solar Thermal, 7.5 cr</td>
</tr>
<tr>
<td>EG3008 Photovoltaics, 7.5 cr</td>
<td>EG3006 Design of PV/Hybrid Systems, 7.5 cr</td>
</tr>
<tr>
<td>EG3005 Economics of Solar Energy, 2.5 cr</td>
<td>MÖ4003 Energy Storage, 5 cr</td>
</tr>
<tr>
<td>EG3013 Applied Solar Energy, 7.5 cr</td>
<td>EG4003 Scientific Communication, 5 cr</td>
</tr>
<tr>
<td>EG3007 Solar Thermal, 7.5 cr</td>
<td>EG3004 Social Context of Energy Systems, 5 cr</td>
</tr>
</tbody>
</table>

ESES Second year Curriculum:

**Optional Summer Courses**

- EG2007 Global Perspectives in Solar Energy, 5 cr (summer course with varying topics every second year)
- EG3017/18 Solar Energy Internship, 7.5 cr or 15 cr

<table>
<thead>
<tr>
<th><strong>Autumn 3rd semester</strong></th>
<th><strong>Spring 4th semester</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>EG3012 Sustainable Energy Systems, 5 cr</td>
<td></td>
</tr>
<tr>
<td>EG400x Solar Building Design, 5 cr</td>
<td></td>
</tr>
<tr>
<td>MÖ4004 Solar Thermal Power, 5 cr</td>
<td></td>
</tr>
<tr>
<td>EG4004 Dynamic Simulation of Energy Systems, 7.5 cr</td>
<td></td>
</tr>
<tr>
<td>MÖ4005 Project Course in Solar Energy Systems or Energy Efficient Buildings, 7.5 cr</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. ESES Master Program curriculum.
4. The Future of ESES

Today, the future development for the ESES-program seems positive. These are the current applications for the years 2017-18 and 2017-19:

ESES 1-yr program (60cr) starting in September 2017: 159 prio-1 applicants; out of them 77 accepted; out of them 8 expected to join in September.

ESES 2-yr program (120cr) starting in September 2017: 344 prio-1 applicants: out of them 114 accepted; out of them 29 expected to join in September.

Presently an application is being prepared for the KK Foundation (KK = Stiftelsen för kunskaps och kompetensutveckling – knowledge and competence development) for developing an internet-based program.

Plans for coming years:

• Implementing solar electronics and other course options in the program
• More opportunities for study exchange semester and thesis at partner universities
• Further intensified collaboration with solar industry
• Summer internship
• International Master with a couple of Partner Universities
• And, possibly, within some years, a PhD program in Solar Energy Engineering.
References


Fiedler, Frank (2014). ESES 15 Year’s Perspective. PPT-presentation at the 15-year anniversary (unpublished)


ESES on the web: www.du.se/en/solar
ESES on Facebook (open): www.facebook.com/groups/ESES1011/?fref=ts
ESES on LinkedIn (closed): www.linkedin.com/groups/123655
On the alumni networking of the
Postgraduate Programme Renewable Energy
at the University of Oldenburg

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Abstract

Higher education (HE) programmes and their home institutions establish alumni networks to keep in contact with their graduates. Objectives to run such networks may stay undefined and rather general. An investigation was carried out to analyse the field of activity and features of the alumni network of the Postgraduate Programme Renewable Energy (PPRE) at the University of Oldenburg, DE. Focus was put to the approaches to run and nurture such a network as well as on the user behaviour. The network was established close to the start of the programme in 1987 in form of a closed and supervised emailing list. The PPRE alumni network is formed by 560 alumni from all batches since the programme start. Responses to a survey were returned by 28% of the alumni, naming different interests in the use of the network. Results indicate a positive, self-perpetuating process of the network development and programme recognition.

Key words: alumni network, university network, higher education programme, graduate, resource demand, quality assurance, study programme

1. Introduction

Alumni networks carry the potential to benefit both the offering institution and its alumni. A basic feature of alumni networks is to create a community, with which the addressed group of graduates can identify themselves (Bardon et al., 2015). Alumni networks addressing heterogeneous groups of alumni present themselves specific in their objectives, like e.g. the Alumniportal Deutschland (Federal Ministry of Economics and Development, Germany, 2017). Numerous features address potential interests of alumni, e.g. closed discussion groups for a self-identification to sub-communities. The acceptance of the network is shown to the user community by the number of users, updated blogs and other contributions.

Another format of outbound networks are alumni networks run by the institution of higher education. The institution’s alumni network is set up to attract its graduates, while the alumni are mostly anonymous to each other. Objectives to run such a network may stay vague to the operators, users, or interested newcomers. The operation of the networking platform and thus the communication process can be based on a third party business server (University of Oldenburg, 2017).

In contrast to alumni networks addressing distinct backgrounds are those run by the HE programmes, which are based on a closed environment and community, and are not visible to the public. Such HE programme networks are not in need to seek for members but incorporate
coming generations out of itself. The alumni network of the Postgraduate Programme Renewable Energy, PPRE, is of this format. The authors, being past and present staff members of PPRE, started an investigation on the features and details making up for the success of the PPRE alumni network. The research hypothesis was, that moderated, multilateral networks formed by alumni - as well as by the alumni and the former home institution - have the potential to create overarching benefits for all actors and users likewise, reaching out in quality assurance and permanent development of the programme itself. An online survey communicated to the alumni was carried out in order to quantitatively and qualitatively investigate the users’ networking behaviour. Interviews with staff members of PPRE delivered information from the operator’s side. Staff interviews and reflecting processes investigated quantitatively and qualitatively measurable benefits and drawbacks for the programme. Findings of the study indicate that the process of alumni networking results in added values beyond factual and social community bands.

2. Methodology

The analysis of the PPRE alumni network was carried out to investigate existing features, activities, and factors that support the network in a way, which is characteristic for the three decades of its existence. The chosen internal evaluation formats were an online-based survey on the user behaviour within the emailing list, and semi-structured interviews with programme operator, administrators and contributors to the programme, focussing on activities and human resource demand.

The survey was sent to 560 alumni from 83 countries still represented within the emailing list based network since 1987. The network incorporates PPRE alumni and the alumni from the European Master in Renewable Energy (EUREC), who have been hosted by PPRE during the first semester studies at University of Oldenburg (UO). Students of the current batches are also included in the network.

![Figure 1: Methodology analysis of PPRE alumni network features (source: authors)](image)

An additional screening and evaluation of the programme activities served to identify descriptors for the quality of the programme. The screening of past and ongoing activities was retrieved from the PPRE statistics and archive, including information on national and international programme activities (Figure 1). The authors’ experience as contributors to current or former quality management of PPRE, international workshop and summer school development, and management within the programme, as well as lecturing activities, student and alumni counselling, is included to the evaluation of the results.

Personal communication with alumni working in the university environment and with external senior staff from other HE programmes served to compare and weight the retrieved information and contributed to single aspects of the evaluation.
3. Results

The start of the network in 1988 was based on the *alumni initiative* of the first students, wishing to stay in contact beyond the end of their studies. Since then, the PPRE alumni network is founded on a time and human resource intensive managing and maintaining work, rising with the number of graduates. Thereby the programme committed itself to a content oriented networking within and for the network (Figure 2), which is based on the emailing list. The information retrieved feeds the statistics on whereabouts and career development of the alumni.

Figure 2: Schematic view of the alumni networking areas divided into managing and content oriented activities (source: authors).

The management of the network ensures a smooth and reliable operation of the communication between the programme and the alumni on an up-to-date database. Work force from programme’s side today add up to 2.5 person months per year. The network is the basis for internal networking communication as well as manifold outbound activities which are organised today by the programme, the alumni, and student groups. Such outbound activities started as early as 1993 with the first alumni seminar organised in Nairobi, Kenia, and are reflected in students networking engagement nowadays (Students of the University of Oldenburg, 2015).

3.1 PPRE Alumni Networking Activities

The emailing list serves two main networking features: the database and the annual newsletter. PPRE’s emailing list is anchored within the DFN (Deutsches Forschungsnetzwerk), offering safe server access and long lasting availability of online communication service, free of costs and independent from business oriented service models. The maintenance of the emailing list by the PPRE operator cares about netiquette, spam control, and annual updating of the member list on request.

A survey was sent to alumni and students of PPRE and EUREC in January 2017 in order to collect quantitative data and content oriented information on the behaviour of users of the emailing list. Replies were returned by 28% of all members of the emailing list (159) within two weeks, representing alumni from 47 countries of which 80% are from outside Europe. The results of user behaviour show, that one half of the repliers (80) are active in the network while the second half of the repliers defined themselves as “reader only” (77). (Figure 3). Two repliers did not give further information. The user behaviour of the total group of repliers was further evaluated with respect to the personal interests and the respective weight of importance. Results show multilevel interest reflected by 372 references (Figure 4). While general interest on information about the development within the renewable energy (RE) sector can be assumed (107 statements), there are three further areas of main interest (54 to 68 answers each (Figure 3)):

- Networking within the status group „PPRE Family“
- Information on worldwide job offers
- Personal support on subject specific issues, career development and others

Evaluation of the importance of the categories by a weighted average analysis shows that each category carries medium to highest importance for the user (Figure 4).
Additionally, the evaluation of communication paths via the emailing list identifies a strong exchange amongst the members themselves on job opportunities, PhD positions, RE projects and RE subject specific requests, support requests and offers, discussion rounds, and requests for meetings at international conferences. Furthermore, external training and Master thesis places for PPRE students are regularly communicated from alumni to the programme operator.

Since 1991, the annual newsletter collects information from and distributes information to PPRE’s alumni and to interested institutions and thus develops a broad kaleidoscope of the involvement of alumni in the RE sector worldwide. The spectrum of information encompasses career development of its graduates as RE experts as well as activities at and news from the University of Oldenburg and PPRE. Alumni contribute with reports of activities at their institutions and their countries. The network operator collects news from the programme and the University of Oldenburg, edits submitted reports and organises the publication. The newsletter contains an updated emailing contact list.

### 3.2 PPRE alumni network success factors

Semi-structured interviews with the network operator and staff members delivered further aspects of a positive feed-back loop regarding the introspection of the programme and growth and stabilization of the network. While the programme is in a loose but reliable contact with the whole group of alumni, it is supporting intensive exchange with those alumni, who are looking for extending the cooperation with PPRE, or who want to establish regional RE related networks in their countries. These intensive bilateral contacts also help the donors, like the German Academic Exchange Service (DAAD - Deutscher Akademischer Austauschdienst), to develop networks of high level experts. Since 1993, such funding schemes put the programme in the position to cooperate in 6 international alumni seminars organized by their graduates (Kenia (2), India, Chile, Indonesia, and Bangladesh) and to conduct 3 additional seminars at University of Oldenburg. As early as 2006, the cross-linking to diverse alumni networks, especially oriented towards developing countries, like the DAAD supported postgraduate programmes’ network (AGEP) and networks of NGOs, supported the conduction of international summer schools at University of Oldenburg. Such summer schools addressed either specific or interdisciplinary key topics (e.g. “Photovoltaics”, 2006; “Water, Energy and Sanitation”, 2013). Along with this development of international multi-day events, it was possible to win...
donors like the International Renewable Energy Agency (IRENA) or the Ministry of Education and Research of Lower Saxony, Germany, to give support for travel grants for participants and further support. The overall process led to a steady increase in the name recognition of the programme and its number of cooperating partners. As a consequence, the PPRE programme was even forced to decline a number of requests for cooperation due to limited financial and human resources.

Beyond the outbound activities, the network also serves to integrate alumni experts directly into the educational activities of PPRE, e.g. by funding research stays at which the alumni contribute with their research results and expert knowledge to the lecture courses. Feedback given by students, recent graduates, and alumni through the overall communications via the network is reflected in the daily work of the programme. It is used for the future orientation of the programme and for stabilizing and extending the network activities.

4. Discussion and Conclusions

The objectives, features, and outcomes of the alumni network of the Postgraduate Programme Renewable Energy (PPRE) were investigated by a survey, semi-structured interviews with the operator and staff members, as well as by a screening of past activities. The evaluation gave insight into the alumni network as a complex tool serving the programme development, the personal alumni career development, and the development of regionally acting alumni networks worldwide. Results of the evaluation show that alumni develop a very strong attachment, exemplarily reflected by the high number of references to the survey answer category PPRE networking, indicated as “PPRE family” or by frequently notifications of internship and master thesis places worldwide offered or forwarded by alumni experts to the current students.

Evidence is given that a permanent evaluation of the network information through the higher education (HE) programme can be used to identify and present competencies and specific features of the (HE) programme to others. The investigation showed that all activities are based on an up-to-date information flow retrieved and distributed preliminary by the emailing list and the annual newsletter. This information flow is organised from the home institution to the alumni, from the alumni to the home institution, and also among the alumni of all batches, also including the actual students. On the programme’s side the received information is fed into a data base. This database allows the programme to execute statistics on the number and kind of job positions related to renewable energy and career developments of their graduates in the sectors of research/education, industry/business, governmental/non-governmental institutions and consultancies. The information on several hundred individual graduate careers allows an interpretation of the programme’s success and sets the programme’s senior staff into the position to carry out adaptations of the study programme.

It could be shown that maintenance and operation of the alumni network led to a bonding of alumni, benefitting both, the programme and the alumni. Both sides were put into the position to use the network to access high level donor organisations and thus extend their networking and content oriented work. The growing network activities with international partner organisations point out the reliability of the programme, on the one side, and numerous alumni, active in further cooperation seeking, on the other side. The results indicate that, if the information flow within the network is used for a self-reflecting process related to the objectives of such a network, then the network carries the potential to grow and develop by the number of members and by quality of content-oriented exchange. Thus, evidence is given, that financial and human resources to run such a network should be justified, if objectives are set clearly.

From this survey and further literature study evidence is given that well-run alumni networks
are the basis for HE programme development, and that alumni and HE programmes benefit beyond the educational phase. It is concluded from the findings that the PPRE alumni network brings the programme into the position to deliver a transparent picture of its activities, objectives, achievements and competences. Moreover, it was found that the necessity of alumni networks is anchored in their potential to function as multi-directed pool of information, knowledge, and competences. Information on alumni whereabouts can serve as a return flow of information to donor organisation in the educational sector, providing assurance to the politics of the donating institution, as shown in the DAAD review of three alumni surveys (Golba 2013). The review report evaluated information about the whereabouts of the alumni, regarding the effects of individual financial support of thousands of international students in Germany by DAAD since 1987. Here the focus was on the alumni’s career and the renewable energy sector development in the respective home countries. Finally, it was also found that well-run alumni networks have the potential to develop new features of networking, as it has been shown for student-alumni-peer groups, linking experts’ knowledge to students in distance education programmes (Driouech et al. 2015).

References

AGEP, German Association of Postgraduate Programmes with special Relevance to Developing Countries. Accessible: http://agep-info.de/about-us/, last access: 27.05.2017.


Development of a holistic method for assessing success of renewable energy study programmes

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Abstract
Quality monitoring and success assessment of academic study programmes is beneficial to satisfy the needs of students, lecturers and employers of the graduates. However, the diversity of processes involved (e.g. coaching, competence development or further training for lecturers) among the main actors (educational institutions, learners and professionals) make quality assessment on study programme level a complex and challenging task. The integration of different stakeholders’ views onto a quality assessment mapping is desirable for allowing a holistic understanding on the main success factors of a study programme.

In this paper a methodology, originally proposed to measure success of the implementation of Solar Home Systems amongst various stakeholders is applied to develop a first approach for assessing quality and success of Renewable Energy (RE) higher education programmes.

Key words: success and quality assessment, quality monitoring, study programmes, higher education programmes, renewable energy

Nomenclature
FAHS Fachausschuss Hochschule (expert committee higher education of the German Solar Energy Association)
HE Higher Education (Master studies or beyond)
HEP Higher Education Programme
m. & p. methods & problem
PPRE Postgraduate Programme Renewable Energy www.ppre.de
RE / RET Renewable Energy / Renewable Energy Technology
SEM Sustainability, Economics and Management https://www.uni-oldenburg.de/en/sem/
SSG Self-Set Goal
UOL University of Oldenburg, https://www.uni-oldenburg.de/

1. Introduction: the necessity of a holistic assessment framework

Quality monitoring and success assessment of academic study programmes is beneficial to satisfy the needs of students, lecturers and future employers of the graduates. Extensive literature exists on the definition of “academic success” and its operationalization for assessment (Jacobi, 1991, Dai and Song, 2016, York et al., 2015). Definitions of the term are often broad and complex, reflecting the complexity of processes and stakeholders involved (York et al., 2015). In this paper, the theoretically grounded definition developed by York et al. (2015) is taken as a starting point for developing a conceptual frame for understanding success drivers for higher education programmes (HEP) in the field of Renewable Energy (RE).
Six key components are comprised in their definition of “academic success”: academic achievement, satisfaction, acquisition of skills and competencies, persistence, attainment of learning objectives and career success (York et al., 2015). This definition, as most of others present in literature, is mainly student-centred: success is defined with respect to the student's performance, achievement and development during his or her university studies. Students are indeed key actors in the context of “academic success”. However, they are not the only ones involved when discussing the success of study programs. So is, for instance, career success often defined in terms of job offers or salary. Nevertheless, these indicators say little about the performance of a RE graduate in particular tasks, which might be of utmost importance in that professional field, such as problem solving or facing complex systems solutions. In addition, precisely a graduate’s performance on these tasks would define the “success” of a university programme from an employer’s perspective.

The challenge in this context is to develop a multi-perspective method for understanding the most relevant outcomes and factors influencing HEPs’ success and quality in the RE field. Such a method would enable key-stakeholders involved to get feedback on paths leading to success or failure and to understand main driving success factors of an RE educational programme.

In this paper a methodology, originally proposed to measure success of the implementation of Solar Home Systems (SHS) amongst various stakeholders is applied to develop a first approach for assessing quality and success of RE higher education programmes (Holtorf, 2016). To ensure a multi-perspective approach, students, lecturers (faculty) and professional experts have been considered as main stakeholder groups involved.

2. Methodology

Three different stakeholder groups were addressed: educational institutions, learners and professionals. Since the aim of our study was to get a first holistic mapping of success factors and expected programme outcomes from the stakeholders, guidance based surveys were used as a research approach. The qualitative methods of data collection can be used on an explorative manner, allowing the generation of first hypothesis on a research topic. Here the information was sought by workshops with stakeholders and by questionnaires sent to the research participants, refer to Figure 1.

Figure 1: Methodology of the research.
Guided interviews were conducted on an individual basis for the professionals’ stakeholder group by means of an open questionnaire. 28 experts both from companies and the academia working in the RE field were addressed. The students and lecturers were approached by means of guided interviews in separate workshops. Students from the EP, PPRE and SEM Programmes of the University of Oldenburg (UOL) were addressed. The results of this group of respondents is prone to a selection bias as solely the views of students of the UOL was sought. Interviewed lecturers come from 21 universities in German-speaking countries offering RE programs. They are engaged in the FAHS. 30 out of the 120 members of FAHS contributed to this paper. (Bruder and Holtorf, 2017).

The guided interview addressed the following topics:
- Self-set goals regarding the graduates and the programme
- Related importance of those goals
- Success factors influencing the identified goals
- Possible measurement criteria and scales for the achievement of the self-set goals.

3. Results

The following sections present the results of the participants’ answers.

3.1. Self-Set Goals

Figure 2 shows the self-set goals of the stakeholder groups junior experts (less than 3 years of professional experience), senior experts (more than three years of professional experience), and students (MSc. & PhD). Figure 3 shows the self-set goals of the lecturers group.

![Figure 2: Self-Set Goals of higher education beneficiaries.](image-url)
Junior and senior experts address similar self-set goals and weighing related to HEPs. However, they differ in the categories leadership skills and specialization. MSc. students and PhD students are contrastive in their self-set goals. Finding HE programme is an important matter for MSc. students while PhD students did not opt for this goal.

![Figure 3: Self-Set Goals of higher education donors.](image)

Obviously, lecturers’ goal is mainly to generate competences (m. & p. solving comp. = methods and problem solving competences) while students wish to obtain those competences. While lecturers weigh their personal contentment high, students wish to get involved in a wider frame.

“Save the world” is a direct quote of a MSc. respondent.

3.2. Success Factors

Success factors refer to individual self-set goals and describe influencing positively the achievement of self-set goals from stakeholder’s perspective. However, in this specific survey many success factors have referred to multiple self-set goals. Success factors are either endogenous (the stakeholder is responsible for the success factor and may influence it) or they are exogenous (no influence of the stakeholder).

Figure 4 represents all the success factors for HEPs listed by the respondents. The manifold responses were sorted by exogenous and endogenous success factors from the point of view of the stakeholder groups lecturers, students and experts. Lecturers see the biggest portion of contribution to the success of HEPs in their own responsibility. Their didactical concept, their knowledge or even their capability to entertain students made up for 54% of all listed success factors summarized in lecturers’ characteristics.

Students’ responses were more differentiated. Hands on experience (30%) including labs, excursions, or participation in conferences and exhibitions have the highest impact on the success of HEPs. The comprehensive curriculum includes a sound structure of the programme, time for studying, exam preparation and exams, group work and even balancing time for working and fun. With hands on experience, comprehensive curriculum, experienced lecturing personnel, HEP’s infrastructure (lab setups and availability of up to date software), information & consultation, 77% of the success factors are exogenous from the point of view of students (MSc. & PhD). In contrast, only 13% of the success factors are students’ endogenous success factors including students’ motivation & dedication, a fair distribution of tasks in group work, personal time management, learning competences and the interaction with colleagues summarized in students’ characteristic. The diversity in the team (4%) links the HEP and the student related success factors. It includes the diversity of the students (refer to the HEPs’ student selection process) as well as of the lecturers. It also refers to the language used in the programme as well as the language competences of the students and lecturers.
The experts mention three main success factors, namely students’ education (including curriculum, state of the art course content and course assignments) and students’ hands on experience as well as the lecturers’ capability. The three success factors are exogenous from the point of view of the respondent experts. The experts listed no endogenous success factors.

### 3.3. Measurement of Success

It was observed that this was the most difficult part for the participants. Solely the lecturers were able to propose consistent measurement guidelines and measurement scales for the level of achievement of their self-set goals. However, many self-set goals listed by the lecturers were of qualitative nature. The challenge was to transfer the level of achievement of qualitative self-set goals in to quantitative figures. The exams’ grades and the average grade of a batch’s exam is an example for the measurement of success. Lecturers proposed grades as a measurement guideline for evaluating the level of achievement of their self-set goal to transfer their knowledge to the students. An average grade of >95% of a batch’s exam was referred to as “self-set goal fully achieved”; an average grade of <50% referred to “full failure”. A linear approach was decided on for evaluating the level of success for marks in-between. Therefore, an average grade of 72.5% would render a level of achievement of 2.5 on the scale of 0=failure to 5=fully achieved. Other scales could be logarithmic or exponential (Holtorf et al., 2015).

### 4. Discussion and Conclusion

The measurement of success of a higher education programme by involving multiple stakeholders is beneficial for self-monitoring in order to close the feedback loop and in order to improve programmes and finally stay competitive. Nevertheless, it remains a complex task. The diversity of the topic and the diversity of the stakeholders (leading to a diversity of self-set goals), the determination of the measurement guideline and the measurement scale are difficult as very often qualitative categories are in use. The answers obtained show the different perspectives from the stakeholders involved. Particularly different is the students’ view on the defined major outcomes expected from a HEP (self-set goals). Students’ answers show a strong focus on the content (general knowledge on RE, RE topics in a wider frame or generating relevant results) and on the study experience itself (diverse environment, personal development and networking). Current academic success assessment literature (York et al., 2015) focus on this students’ cantered approach, showing a great diversity of tests and items from both of these arenas.
Results about the major competences or outcomes that shall be obtained in a HEP on renewable energy answers from educational institutions and professionals are in line. The results show an enhancement of the previous students’ perspective: besides the obvious acquisition of general technical knowledge, scientific and method competences, great importance is given to social competences such as team or networking ability as well as to autonomous learning/working ability. York et al. show in their extensive literature review on academic success measurement, however, that most research concepts in the field and their related measurement tests concentrate on individual competences (York et al., 2015). These are either related to subject-specific items or more generally to self-efficacy perceptions and students’ satisfaction. However, neither key social competences nor attitudes towards autonomous learning are mentioned. Since these seem to be key outcomes of HEPs, further research would be necessary to properly address their importance and develop suitable measurement instruments.

Students’ characteristics such as study engagement, previous knowledge or perceived self-efficacy are a major success factor, ranging from 41% to 13% share depending on the lecturers’ or students’ perspective. Thus, students’ awareness for their responsibility to the success of HEPs might significantly contribute to the success of HEPs from this stakeholders’ side. Similar contribution is shown by “hands-on experience”, weighing 30% and 14% from the point of view of the students and experts respectively. Listed success factors, both by the students and experts indicate a demand for the involvement of experts’ engagement in lectures, enabling internships or invitations to excursion visits at their companies.

But the greatest success factor by far awards to the lecturers with 54%, 17% and 67% corresponding to the educational institution, learners and professionals respectively. Thus, lecturers can greatly contribute to the success of the programmes in which they are teaching by assuring state of the art contents in their courses as well as by continuously improving and carefully choosing suitable didactical concepts.

Results from a first holistic mapping of HEP success involving three stakeholder groups addressed here show a valuable enhancement to current success assessment views regarding the importance of social and team competences. However, results about the success factors as well as the measurement of the level of achievement of self-set goals (the success) show that some of the interviewees could not identify related items. Thus, further research is required for precisely identifying success factors, their influence on the different defined self-set goals and the measurement of success. For this aim, individual guided interviews for the three stakeholder groups would be valuable.

References


Development of Master courses in Renewable Energy and Energy Efficient Buildings in universities outside EU

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Abstract

Lund University has during the last 10 years been working with development of university courses and master programs in universities outside EU. The field has been within renewable energy and energy efficient buildings and so far more than 25 universities have been involved. The work has been funded by support of European Commission within the Tempus programme and after 2015, the action Capacity Building in Higher Education (KA2) in the Erasmus+ programme. Master program started in, among others, American University of Beirut, Cairo University, 11 universities in Central Asia and Russia with more than 250 students starting the program, project ongoing in Nepal and in Bhutan. The programmes has been successful and sustainable in the sense that most of the programmes are still active.

Key words: Erasmus+ project, master course development, international cooperation

1. Introduction

Lund University has during the last 10 years been working with development of university courses and master programs in universities outside EU. The field has been within renewable energy and energy efficient buildings and so far more than 25 universities from Lebanon, Egypt, Jordan, Russia, Central Asia, Nepal and Bhutan have been involved. The work has been funded by support of European Commission within the Tempus programme and after 2015, the action Capacity Building in Higher Education (KA2) in the Erasmus+ programme, EACEA (2017).

2. Background

The Division of Building Physics at the Department of Building and Environmental Technology at Lund University has been involved in six Tempus and Erasmus+ projects, where four of them were coordinated from Lund. The constellations of involved universities and countries has changed from project to project. The projects always includes a minimum of three universities from Europe and from the beginning at least three universities from countries neighbouring EU. The eligible partner countries have expanded and is now also including e.g. Asia, Latin America and Africa.
The receiving universities has been located in Lebanon, Egypt, Jordan, Kyrgyzstan, Tajikistan, Kazakhstan, Russian Federation, Nepal and Bhutan. A common factor for all of the countries is the high availability of solar irradiation. This was early identified as a key component for the possibility to build energy efficient buildings. Using active solar technology was something all partners in the projects recognized as a technique with great potential.

3. Activities

The overall goal has been to strengthen the education at the receiving universities. This was carried out differently for the various projects. However, the idea has been to establish new master courses and master programs, as well as in one project diploma courses, in renewable energy and energy efficient building technologies and design.

3.1. Lebanon 1

In the first project in Lebanon, the American University of Beirut was developing and starting a master program, but also the Lebanese University and Beirut Arab University were partners in the project. The main objective was to develop a master program in renewable energy and efficient building technologies aimed at a multidisciplinary student target group, based on interactive learning and teaching. The possibility to support the teaching with a laboratory component was regarded as very important and both a testing house as well as an indoor laboratory for measurements was constructed.

3.2. Egypt

In Cairo University and in Shorouk Academy, both in Egypt, the objective was to develop a professional diploma programme in energy efficiency and renewable energy in buildings and a master programme in energy efficiency and renewable energy in buildings. The project also focused on developing interactive instruction techniques for lectures and laboratory courses. The project was also concerned with extending the laboratory services and training in collaboration with the local and regional industry and community.

3.3. Jordan

The project in Jordan included; The University of Jordan, Jordan University for Science and Technology and M’utah University. The aim of the project was to establish an accredited master course on renewable energy and energy efficiency following the Bologna requirements. Furthermore the project aimed to improve and diffuse renewable energy and energy efficiency in public and private buildings, according to the national energy plan.

3.4. Russian Federation, Kazakhstan, Kyrgyzstan & Tajikistan, MAPREE-project

From each of the recipient nations in the project there was three universities. From Russia there was Moscow State university of Civil Engineering, Kazan State Architecture and Construction University and Nizhny Novgorod State University of Architecture and Civil Engineering. From Kazakhstan there was Kazakh Leading University of Architecture and Civil Engineering, Almaty University of Power Engineering and Telecommunication and Auesov South State University Chimkent. From Kyrgyzstan there was Kyrgyz State
University of Construction, Transport and Architecture, Naryn State University named after S.Naamatov and Osh Technological University named after M.M. Adyshev and finally from Tajikistan there was Tajik Technical University named after academician M.S.Osi, Khujand Polytechnic Institute of Tajik Technical University and Technological University of Tajikistan. Included in the project was also various governmental and industrial partners. The main objectives were to develop new master programmes on renewable energy and energy efficiency in buildings according to the Bologna three cycle system and the European credit transfer system, to develop appropriate laboratory components and field experiment tools based on interactive learning and teaching, to establish training courses for professional civil engineers and architects in the areas of applied energy for buildings, to promote technological and scientific co-operation between universities and construction and other companies on renewable energy and energy efficiency in buildings and to strengthen the collaboration between the participating universities from EU, Central Asia and Russia, mapree.se (2016).

3.5. Lebanon 2

Three universities from Egypt; American University of Cairo, Helwan University and Suez Canal University and two from Lebanon, American University of Beirut and Lebanese American University participated in the project. The project focused on establishing a joint/professional degree for an innovative engineering field (Green technologies) among project partner institutions with three major concentrations, namely: Green Energy, Green Buildings and Water. The objectives were to develop study program & the curriculum for a professional degree in green technologies, to develop a lifelong learning courses for a professional degree for SMEs in the green technology field, to design a scheme for comparability, compatibility and alignment of the developed degrees with Bologna Process. The project was also aiming to train partner countries professors and to develop of a platform for blended learning.

3.6. Nepal and Bhutan

In this project there was two universities from Nepal; Kathmandu University and Institute of Engineering Tribhuvan University. From Bhutan there was only one university, College of Science and Technology, Royal University of Bhutan. Having only one university is normally not allowed. However, as Bhutan only had one university at the time of submitting the application there was made an exception for this case. The main objectives in the project is to develop an interdisciplinary master course on energy efficient building technique and to develop elective courses in energy efficient building technique and courses for engineers and architects already in the field. Specific attention was paid to development of laboratories at each of the universities for hands on training for students. Furthermore the project aims to promote technological and scientific co-operation between universities and companies and to strengthen the collaboration between the universities from EU, Nepal and Bhutan, cimceb.se (2017).

3.7. Laboratories

A key component in all of the projects has been the establishment of laboratory facilities and equipment. This has for instance been to establish laboratory testing of solar thermal and PV technology as part of the syllabus. Other established laboratory tests have been to analyse the air quality in indoor environments and to measure thermal losses and thermal bridges in
building skins. Figure 1 and Figure 2 shows different types of measurement facilities and equipment that is used within the various projects.

![Figure 1 and Figure 2](image)

**Figure 1.** Left, test house for energy efficient building measures located on a roof on Mechanical department in the American university of Beirut. Right picture, laboratory equipment stored correctly according to the EU-rules. In charge of the equipment is Professor Farrukh Aminov at Khujand Polytechnic Institute of Tajik Technical University.

**Figure 2.** Laboratory equipment for PV, American university of Beirut (left figure) and PV laboratory testing rig in the laboratory in Kazan State University (right).

### 3.8. Staff and student training

One important activity in the projects is training of staff and students. Staff from the partner universities comes to Europa and the European partners gives short intensive courses in possible requested subjects. Also selected students are given the possibility to go to the partner universities for short visits, training in specific subjects as well as study visits to appropriate places and activities.

### 4. Outcome

Some of the results from this type of project is not possible to quantify. This can for instance be new pedagogic cooperation between partners in the projects or even inspiration from the project for various new ideas. Alternatively it could be research collaborations between the
project partners or between industrial partners and university partners. However there are results from the different projects that are tangible.

The following list is concrete outcome from the MAPREE project. Master programmes started in 11 universities in Central Asia and Russia with more than 250 students starting the program. The programme has increased its number of students over time. In 2014 there was 14 students starting the different master programmes, in 2015 the number had reached 112. In 2016 it had further increased to 142 students. One of the partners never started any programme and one of the universities had too few students to start the programme 2016. However, this partner aims to restart the master programme for 2017. Taken together the project appears to be sustainable and growing in the total number of students that start the programme. All the data is shown in Figure 3 below. The most successful university, in terms of number of students, has had almost 100 students since the programme started.

For the project ongoing in Nepal and in Bhutan, early results shows that the industries in the countries considers the master programs as important. The programs are intended to start 2017 at the Royal University of Bhutan and at Tribhuvan University in Nepal and 2018 at Kathmandu University in Nepal.

4.1. Success factors

The most important in order to succeed with this kind of project is to find a committed partner and form a group of persons that are really interested in the field. Also the language skills are crucial.

In order to get funding, the area must also be “prioritized” by the local authorities. Renewable energy as well as energy efficient buildings are often high up on that lists.

4.2. Challenges

In order to get into this kind of projects, you have to be prepared to meet a lot of unexpected issues. Be prepared for (financial) systems that collide; EU/partner universities/EU
universities/own university. The financial regulations in this projects are very specific and in many parts very different compared to other kind of EU-projects.

Many of the countries are also political unstable and different kind of travel restrictions have been experienced. The time line for the first project from idea to audit in Lebanon lasted for about 10 years. From the first preparation in 2004 and after funding it started 2006 – more or less at the same time as the conflict with Israel started. This delayed the first meeting in Lebanon that could be held first in 2009. The project was delayed for one year, ending in 2010. After some years an EU-audit checked the finances and the project was finally ending in 2014.

The project in Egypt was ongoing during 2011, when the demonstrations during the Arabic spring was intensive. The project could be finalized, but the new built laboratories in Cairo were destroyed during the revolution.

4.3. Reflections

This kind of projects gives a great opportunity to spread knowledge and research results to countries outside Europe. The staff, students and the non-academic partners are very interested in the sustainable development and they will spread it further into the society. But it is also a fantastic way of meeting new people and colleagues in the same field, getting to know new cultures and meet the unforgettable hospitality in so many places.

This contacts also means possibilities for continued joint projects, international cooperation, build “bridges” around the EU and open the eyes of the outside world.

By meeting and working with people with different cultural backgrounds but with similar ambitions and similar issues will also promote tolerance and respect, equality and democracy.

5. Conclusions

In conclusion, the method has been very successful in order to establish new master programmes in renewable energy and efficient building technologies. Not only has a considerable amount of programmes been initiated but the results also shows that the structure has been sustainable in the sense that most of the programmes are still active.

6. References

mapree.se (2016), MAPREE’s official website [online] Available at: www.mapree.se [Accessed 10 May 2017]
cimceb.se (2017), CIMCEB’s official website [online] Available at: www.cimceb.se [Accessed 10 May 2017]
Smart windows of the future.
The introduction of graphene in transparent photovoltaic

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Abstract
The theme of the paper concerns the photovoltaic applied to the windows, the so-called transparent photovoltaic. There are several technologies applied to transparent photovoltaic such as silicon gel or organic transparent photovoltaic, but this research intends to emphasize the last frontier of transparent photovoltaic with the introduction of graphene, a material more tough than the diamond, totally transparent and could lead the electricity with a thickness comparable to that of an atom with considerably reduced costs compared to traditional materials.
An Italian research team has realized the first large graphene photovoltaic panel based on dye-sensitized solar cell technology (DSSC). In this study, the platinum, normally present in this type of photovoltaic modules, has been entirely replaced by graphene, with a cost reduction of about ten thousand times. Graphene, in the form of ink, has been applied to the panel by spray deposition, a method that is easily scalable even at industrial level. The advantage of this technology is that it can be further implemented with higher energy performance and, furthermore, the production techniques of graphene panels could already easily be produced industrially without modifying the production lines and without significant investments in machines or infrastructures.

Key Words: Graphene; Transparent Photovoltaic; DSSC; Smart Windows

1. Introduction

The 40% of the consumption of sources of primary energy in Europe depends on buildings, 20% of which is dispersed due to an inadequate building envelope and especially windows. To dramatically reduce the losses of heat of the windows, it has become an imperative when designing new energy-saving buildings or in refurbishment.

The first phase of technological evolution has seen the transition from single glass to double glass windows, and for some time to this part to triple glass. But although this is already a radical change, the real revolution is another: smart windows, a series of new technologies that help control or store the light and heat transferred from outside to inside.

Carbon is present in nature in different crystalline forms called allotrophic. Allotropes have different binding arrangements between atoms, and thus possess different chemical and physical properties. The most common carbon structure is that of the mine of a pencil: graphite. It consists of planar layers of carbon atoms forming a hexagonal mesh pattern in which each carbon atom is bound to another three. A graphite crystal is made up of these layers of carbon atoms stacked parallel to each other linked by weak intermolecular forces.

It was thought, until a few years ago, that it was not possible to isolate a single plane Graphite, in such a way as to be able to carry out electrical measurements.
In 2004, almost for gaming, physicists Konstantin Novoselov and Andre Geim, researchers of Manchester University, showed that a single layer of carbon atoms could be isolated and transferred
to another substrate and that it was possible to perform an electrical characterization. The ‘game’ of the two Russian friends was rewarded with the Nobel for Physics on 2010. The single carbon layer is called graphene.

On 1 October 2013, the European Commission issued a call allocating €1 billion over 10 years to fund research and bring Europe back to the cutting edge of material science: the University of Gothenburg (Sweden) is leading a group of public and private bodies (of 23 different countries) in the patent competition on graphene.

2. Properties and features

Until the discovery of Geim and Novoselov, however, it was believed that such a material could not exist in the isolated state, because it was thermodynamically unstable with respect to the formation of curved structures such as fullerenes or nanotubes. However, there have been attempts in the past for several years to extract the single monoatomic layer from the corresponding bulk material, graphite. When the first device based on a single graphene layer was made in 2004, it was finally open to the experimental validation of the theoretical predictions made on its properties and the results of these experiments are still not surprising and still allow to predict that this material will play a central role in the scientific and technological progress of the coming years.

Graphene is strong two hundred times more than steel. As a conductor of electricity, it works better than copper and is then an exceptional heat conductor. It is almost transparent, but it is so dense that even helium, the smallest atomic gas, can not pass through it. To obtain a graphene grid of one millimeter thickness, three million sheets are needed. It is also an extraordinary electric and thermal conductor.

Graphene is a monoatomic layer of carbon atoms organized according to a crystalline hexagonal cell structure. This basic structure has planar conformation and therefore the monoatomic layer appears as a two-dimensional material. The crystalline graphite structure appears as superimposed graphene layers, which make the graphite easily flak able parallel to the crystalline plane. This peculiarity suggests the possibility of using different techniques to separate plans.

Mechanical exfoliation, to date, is the simplest and most accessible method to isolate graphene flakes of the size of a few microns, useful for basic search of its properties. The isolation of the graphene sheets was initially obtained in an inadequate manner by means of a mechanical exfoliation method known as the 'scotch-tape' method.

In fact, adhesive tape was used to detach graphite fragments from a crystal. Repeating the operation many times on the same fragments, it was possible to obtain thin layers then transferred to a silica substrate (SiO₂). Once obtained these thin layers were examined and some showed a thickness of just one atom.

The second type of approach to the preparation of graphene is chemical exfoliation. So far the researchers' efforts have been directed mainly towards the exfoliation of graphite oxide (GO), a material having the same lamellar structure of graphite. An innovative production technique is that recently developed by Japanese researchers who, using specific bacteria, have been able to achieve the reduction of graphene oxide.
3. Applications and operation

Today, the European Union is so convinced of the potential of this material, has allocated for a billion euro research and has set a roadmap for 2020. It is the most ambitious joint research program ever launched by the European Community: it involves 126 research groups between universities and industries in 17 countries.

Its shape, strength and stability can be used to create materials never seen before, provoking a revolution similar to the one caused by the use of polymers for the last century. The quantum properties of graphene make it a hub for research, while easy industrial reproducibility makes it a good and relatively cheap item for a wide range of applications and services.

Graphene has exceptional chemical-physical properties that make it interesting in a large number of potential applications. It is extremely durable and rigid, transparent and flexible. It also presents, at ambient temperature, an electrical conductivity superior to each other substance. The electrical conductivity of graphene is superior to 10 to 100 times that of conventional conductors, where electrons colliding with atoms dissipate their energy as heat. Graphene is virtually transparent not only in visible light but also in infrared and ultraviolet light (the optical transmission is about 98% of the incident light), so it may be very suitable for the production of touch screen prints on plastic sheets or of glass, solar panels and solar cells.

New types of solar panels currently in development, consist of photovoltaic cells inserted between two layers of graphene. The light crosses the graphene layers and strikes the photovoltaic cell, with the result of generating electricity that is then transported by the graphene.

IIT-CHOOSE researchers have developed a graphene solar module of about 50cm², the largest ever made with this new material, based on dye-sensitized solar cell technology on which both research groups and various companies around the world are investing resources for its development and optimization. In this study platinum, normally present in this type of photovoltaic modules, has been entirely replaced by graphene, with a cost reduction of about ten thousand times. In addition, graphene, in ink form, was applied to the spray-depositing panel, a method that is easily scalable also at industrial level.
The production of electricity from windows and other surfaces exposed to sunlight is possible thanks to the transparent, low cost graphene solar panels created in Italy by the collaboration of the Italian Institute of Technology (IIT) and the University of Tor Vergata.

The research team has in fact made the first large graphene photovoltaic panel and then published in the international magazine Nanoscale a study that illustrates the results of the research, paving the way for a new generation of semi-transparent and low-cost solar panels. In this study platinum, normally present in this type of photovoltaic modules, has been entirely replaced by graphene, with a cost reduction of about ten thousand times. In addition, graphene, in ink form, was applied to the spray-depositing panel, a method that is easily scalable also at industrial level.

In addition, while reducing costs, the panel maintains energy renditions comparable to traditional technology, based on platinum. With some further modifications, energy yields could be considerably increased while maintaining very low costs. In the prototype developed, the used electrolyte (iodine iodide) is ideal for platinum but not for graphene. By replacing an adequate electrolyte, energy performance would drastically improve.

The first applications of transparent photovoltaic systems have already begun for the creation of perfectly insulated windows and with good efficiency: photovoltaic windows can generate less efficient electricity than the classic photovoltaic but have a much easier installation and lower costs: an investment of the kind, according to experts, is recovered over five years. The idea arises from the need to fully integrate photovoltaic power generation plants into buildings: an ideal solution for those applications where it is difficult or impossible to install the photovoltaic system on the roof of the house.

The integration of photovoltaic is in fact a priority not only from the aesthetic point of view of a building, but it is also necessary to improve the productivity of the plants, through the exploitation of surfaces which have so far been completely unused.

In a recent experiment conducted at the École Polytechnique Fédérale of Lausanne (EPFL), researchers have been able to obtain a level of conversion of solar energy to electricity by 32-60% higher than the average of the laboratory, which is about 32% of the average irradiation, which in itself is higher than the best commercial solar cell performance (20% versus 13% of the least efficient ones).

Ultimately, thanks to the graphene, every single photon energizes two electrons, giving way to a cascade effect that converts light into electricity with a finally interesting yield. Some Chinese researchers have created a panel equipped with a graphene layer (a layer of carbon with the thickness of an atom in a structure similar to that of a hive), which also produces energy with rain. When the water touched the surface of the solar panels, ionized ion particles of water (ammonia, sodium and calcium, positively charged) were separated from water to produce electricity. 'Smart' windows capable of producing clean energy. It will thus be possible to make windows and other surfaces exposed to intelligent solar light, capable of producing clean energy from light radiation without blocking the path.

In this study platinum, normally present in this type of photovoltaic modules, has been entirely replaced by graphene, with a cost reduction of about ten thousand times. This is the first prototype of solar panel that uses graphene to reduce costs while maintaining energy yields comparable to traditional platinum-based technology. It is expected that, with some further modification, the energy yield can be greatly increased while maintaining very low costs.
In the developed prototype, the electrolyte used (iodide iodide) is ideal for platinum but not for graphene, with the replacement of a suitable electrolyte the energy performance would drastically improve. Graphene, a material now famous for its incredible properties such as flexibility, conductivity and strength, has always been considered a material that is unsuitable to capture light due to its extreme naughtiness.

Surrey researchers in England, however, have discovered an alternative way to modify the light absorption coefficient of this material by starting from the mothers’ eyes: a series of microscopic protuberances, arranged in a hexagonal pattern, allow these predators to see in conditions of low luminosity and at the same time to escape the predators by channeling the light directly into the center of the eye. Avoiding so that they also generate reflections.

The researchers, having thoroughly studied their operation, created a graphene sheet using a metallic matrix with nano-structures: the result is a conformation that can channel the light into small spaces between the nanostructures, thus increasing the Luminous absorption from 2-3% to 95%; This also captures the smallest amount of light having a spectrum ranging from ultraviolet to infrared. The potential for such a discovery could have revolutionary results, so it would be enough for a few sheets of graphene to improve the efficiency of photovoltaic panels, allowing the use of electromagnetic spectrum currently unusable.

‘Nature has evolved simple powerful adaptations, from which we have taken inspiration in order to answer challenges of future technologies,’ said Ravi Silva, head of the University’s Advanced Technology Institute. Using this method, our ultrathin coating of nanotextured few-layer graphene absorbs 95 percent of incident light across a broad spectrum, from the UV to the infrared. Solar cells coated with this material would be able to harvest very dim light, said Silva. Installed indoors, as part of future ‘smart windows’, this material could generate electricity from waste light or heat, powering a numerous array of smart applications.

4. Conclusions

‘Smart’ is the most widely used word, in this concept, since technology is finding applications in various areas with the aim of making them more functional. It is now the turn of the windows that, thanks to the integration of semi-transparent graphene solar panels, become ‘smart’ because they are able to store sunlight more efficiently and turn it into clean energy.

One of the obstacles that must be overcome so that it does not remain a material usable in a few applications in the real world, is to be able to produce sheets of graphene sufficiently large to be useful. It is likely that it will take years before you see the possible applications of Graphene realized, the discovery of this ‘wonders’ material provided precedent opportunities to investigate these possibilities.

Currently, carbon-based nanomaterials such as fullerenes and nanotubes are still far from being used in the production of micro- or nano-electronic devices, except for some niche applications. To ensure that graphene is not a purely academic material, with few applications in the real world, the efforts of the scientific community must be aimed at seeking synthesis techniques that can circumvent the intrinsic limitations of mechanical exfoliation and aim to obtain additional information on physical and chemical properties, which identify new applications of this amazing material.
References


Casaluci, Gemmi, Vittorio, Pellegrini, Di Carloa and Bonaccorso, *Graphene-based large area dye-sensitized solar cell modules*.


Influence of diversity in lectures on the students’ learning process and on their perspectives about Renewable Energies in an international context - the students’ view

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Abstract
This paper focuses on student diversity as an enabling factor in renewable energy education and qualitatively examines its effects on the learning process and experience, both during the educational period as well as in career and personal growth. It draws on the experiences of students and alumni of the Postgraduate Programme Renewable Energy (PPRE) at the Carl von Ossietzky University, Oldenburg, Germany: a programme, which has been instrumental in renewable energy education to a diverse student population since its beginnings in 1987, and won the Ars Legendi prize in 2016 for its approach to diversity in learning. The paper discusses various differences in individual, academic and cultural backgrounds, to assess their contributions to the learning process and to the personal and professional development, based on the study participants’ opinions.

Keywords: diversity, renewable energy education, postgraduate programme in renewable energy, PPRE, sustainable energy education.

1. Introduction
The Postgraduate Programme Renewable Energy (PPRE) began in 1987 as one of the first initiatives for promoting education specifically in renewable energy (University of Oldenburg 2017a). Through the years the programme has improved and found new methodologies to provide up to date information in the field. Therefore, the University of Oldenburg works in cooperation with institutions such as: the Centre for Wind Energy Research (Forwind), the Institute for Information Technology (OFFIS), the EWE Research Centre for Energy Technology (NEXT ENERGY) and the School of Computing Science, Business Administration, Economics, and Law. Each one of them have a wide expertise, providing diverse information to the students about the latest findings in each renewable energy field (University of Oldenburg 2017b).

PPRE is currently structured as an 18 month programme with lectures concerning the different renewable energy technologies (wind energy, solar energy, biomass, etc.) and the political, economic and social side of renewable energies. Complementarily, the programme includes hands-on experience on the technical knowledge with different laboratory courses, a
2 months internship and a 6 months master thesis. The students are given the flexibility to decide which renewable energy field and country they would prefer to do their practical training, not being limited to Germany only (University of Oldenburg 2017c).

The PPRE programme has trained over 400 students from 79 countries and it is designed to encourage inclusion in education, making its courses available to students from both universities in Oldenburg: The Jade University and the University of Oldenburg. The authors of this paper, for example, are current and former students from three different continents, speak three different mother tongues and have four different study focusses that were involved in the PPRE lectures and have lived its diverse environment themselves.

This paper focuses on discussing the following question: Is student diversity, based on the student's perspective, an enabling factor in renewable energy education and is it an influencing aspect in the students’ future career? The discussion includes the aspects of various differences in background, such as nationality, academic discipline, gender, language, level of development of their country and cultural upbringing to assess their contributions to the learning process and to the personal and professional development in various career paths.

2. Methodology

A questionnaire on various aspects of diversity was circulated among potential respondents through the PPRE programme's alumni network e-mail group together with a request to respond. The request was expected to reach the alumni network, composed of alumni of the PPRE as well as other allied programmes at the University of Oldenburg. Of the 560 members thus contacted, 19 PPRE alumni and 14 non-PPRE alumni voluntarily responded. The data collected is therefore likely to include a self-selection bias with respondents representing a relatively small sample of the people contacted. In addition to this, questionnaires were also distributed among the current (2015-17) batch of 16 students, whose responses were noted separately after a group discussion session (Current and former students participating in PPRE lectures 2016).

The questionnaire was designed to investigate the impact of diversity on the course and on the respondents' learning experiences. The respondents' opinions on their personal and professional growth in a diverse environment were collected and form the basis of this study. Additionally, regularly maintained records of the PPRE course were accessed in order to quantitatively analyse other diversity-relevant factors such as nationality, gender, previous field of study, sector of employment before and after attending the course and number of applicants (University of Oldenburg n.d.). This data was subject to analysis, both in order to estimate the various types of diversity present within the sample population considered, as well as to identify and quantify long-term data trends.

3. Results and discussion

The question stated in the introduction will be discussed under four major aspects: students’ background, academic structure of the PPRE programme, gender equality and the influence of diversity on students’ skills.
3.1 Influence of diversity in the students’ origins and professional backgrounds in their perspective of renewable energies in an international context

The results of the survey among alumni and current students reveal the considerable impact of regional diversity of the students in the programme on the learning experience of renewable energies and harnessing of locally available resources. The presence of students from differing climatic and geographical areas contributes to a better understanding of the variety of resources available and the multiple ways in which they can be used. This is illustrated by a quote from one of the participants: “One of the courses we took was for us to calculate how much solar radiation we can get in our towns where we come from in our different countries, the results were diverse and very interesting. And once we formed consulting groups [to] try to come out with different renewable energy projects using the resources from our home countries, the results were excellent.”

In addition, there is a definite educational value brought to the classroom by student diversity. The active presence of students from different sectors, many of whom have field and project management experience, enables others to benefit from their knowledge and exposure. While describing the country reports course, as part of which students are required to investigate and present the renewable energy and policy status, in either their home country or a zone of interest, one of the participants wrote: “The country reports were [...] a way to present the situation in our home countries, thereby helping our fellow students to gain some insight of the energy situation in other parts of the world.”

The diversity in the group has also created a large network of professionals around the world, who regularly consult each other when region specific information is required, as it is often the case with engineering, procurement and construction in a global market, or region specific energy standards and policy guidelines. The network enables rapid contact with an expert in the field, whose credentials are verified and with whom there is a shared sense of community and collegial spirit, in spite of the relative anonymity of the two parties, as described by a participant: “Since I’ve graduated from the PPRE University and moved out of Germany to work in international development, my current organization often uses the network of the PPRE graduates located all over the world to find specialists with specific in-country experience.”

Another field where diversity among students was found to have an impact was the interaction between students from developing and developed countries. This is considered particularly relevant given the importance of renewable energy systems for application in sustainable development and the significant proportion of students who pursue careers in the development sector. These interactions play a major role both in terms of the comparison of energy and resource demand and use as well as by bringing together different attitudes to learning and education. As one participant put it: “Students from developing countries have experienced that their teachers are accessible, and it is ok to ask questions [while] students from developed countries seem to learn to be more flexible regarding time, rules, working style, and cultural expectations.”
3.2 Diversity in the academic structure of the Postgraduate Programme Renewable Energy (PPRE) and its influence on students’ career path choices

After finishing the PPRE programme, the students follow different career paths. According to the records of the PPRE course, from 2006 to 2015, 100 out of 191 alumni were working in the industry; 48 alumni decided to be involved in research and education, 30 of whom continued with PhD studies; 37 work in the public sector or in NGOs and development organizations and 6 remained unemployed. 96% of the total number of the students in the mentioned period are engaged in the renewable energies sector.

These different career paths require considerable knowledge of global energy affairs, distribution of resources and policy regulations as well as intercultural communication skills. The fact that the students have a broad spectrum of career-enhancing options proves that the PPRE course is diverse in its structure as well as its content. The international and academic exposure in renewable energy fields, in addition to an effective use of the potential for collective learning, may have played a role as it has been noted frequently by the participants, for example: “The skills I learnt by being exposed to an international and diverse environment enabled me to apply to jobs at international organizations...”

As mentioned in the introduction, the knowledge shared with the students on renewable energy technologies is built by institutions focused on doing research in different aspects related to the technical side of renewable energies. Complementarily, experts in the social, political and economical facets of renewable energies are also involved in the development of the lectures. Hence, the lectures of the PPRE course serve as a window for the students to get a closer look into the theoretical and hands-on basis of renewable energies, and additionally to the work done in the field. As mentioned by a current PPRE student: “the program makes use of a diverse staff of professors and professional who are experts in the field of renewable energy. They teach all the important and up to date and state of the art concepts and research in the renewable energy filed. All subjects are also taught in different ways ranging from theoretical to very hands on.”.

The internship and the master thesis, involved in the structure of the PPRE programme, allow the students to work in the field of their interests. The students often take advantage of the large alumni network to contact different institutions involved in the renewable energy field, during their studies or later in their careers. Furthermore, PPRE participates in initiatives such as the Carlo-Schmid-Programm, where the students can do a 6 months to 1 year internship in an international/development organization like the United Nations. These internships can be undertaken in Germany or in any other country where there are projects led by these organizations, frequently taking place in developing countries. This was noted by a participant as: “PPRE is not only academic driven. It is also in contact with the industry. Having the mandatory period of internship and the incentive to develop the master thesis outside of the university, PPRE pushes practical and professional development of the students.”
3.3. Gender equality in the Postgraduate Programme Renewable Energy (PPRE)

Referring to the internal PPRE statistics, the yearly number of female participants in the programme has shown a fluctuating tendency. From 1987 to 2003, this number varied between approximately 5 to 25% of the students, in the period from 2004 to 2012 it fluctuated between approximately 15 to 40%, whereas in the current batch of PPRE students 50% of the participants were female. Even though, the mentioned fluctuating tendency is present throughout the whole duration of the programme from its beginnings, the percentage of female participants seems to have an increasing trend.

One of the reasons can be seen in the PPRE staff members selecting the annual participants of the programme according to the procedures for equal opportunities of the Carl-von-Ossietzky University of Oldenburg. In the case of equally qualified applicants, decisions tend to be taken in favour of females. From a total of approximately 10% female applicants, approximately 20% or more have been accepted in the last years (MSc. Edu Knagge. Coordinator of the PPRE programme. 2017).

Gender equality is an frequently concerned topic during the lectures. Respect is the main component, including rules such as hearing people out, tactfulness for cultural differences as well as gender related sensitivities and the ban of religious or political discussions in class. Gender equality is further emphasised through the encouragement of female students to take up the position of group managers, who lead five to eight participants in course long projects as pointed out by the respondents. “PPRE has always given equal opportunity to female students and also helped them to stay strong and secure by conducting internal meetings.“, “[...] women were made team leaders in order to teach both men and women that both genders can lead and follow.”.

3.4 Utilisation of the diversity potential and its influence in the enhancement of the students’ skills

As illustrated before, the diversity in PPRE has its source in culture, mother tongue and academic background of its members. However, how can this potential be concretely utilised within the lectures? One example can be the specific structure of the solar energy course. Current students in the PPRE manifested in the survey that: “Students have all the freedoms to realize their idea, technically, scientifically, environmentally, or even socially in many different platforms provided by the university, for example: colloquium, trainings, seminars, workshops, laboratory experiments. In these events, students are stimulated to present their ideas based on their perspective and to brainstorm in solving complex problems.”.

The solar energy course is not restricted to an engineering background. Students from other fields, for example architecture and economics, are welcome to participate and further enlarge the diversity from the perspective of academic background. The course started by reminding the participants of the pre-agreed behavioural rules. English, for example, was further set the exclusive communication language as the one unifying tool. The rules support the learning process on how to behave in an international and diverse group and increase the awareness for
potential conflicts, which is acknowledged: “The programme knows how to bring all these diverse people together to create a flourishing program.”.

In addition, a working atmosphere perceived as pleasant, contributed to an optimal transfer of knowledge among the students. Teacher-centered teaching was avoided and instead various ideas could be exchanged freely within and across groups during the working phases. The fostered, respectful cooperation ensured the freedom and multiplicity of the students’ opinions and the small, interdisciplinary working units supported the sharing of experiences in a natural manner. This eye-levelled working atmosphere enabled inspiring and enriching discussions related but not confined to technical aspects of renewable energies. An architect, for example, could improve comprehension for the practical use and the integration of renewable energy, while a team member with an economic and management background could give additional insight on economic formulas as well as coordination techniques. Both contributed to a new perspective on the given task, as stated by a Non-PPRE participant: “That’s how they learn to channel individual weaknesses and strengths towards reaching the common goal in order to complete the requested tasks like in real working life. The achieved learning objectives are a success for each participant, no matter the state of knowledge.”

4. Conclusions

Based on the opinions of the participants in PPRE lectures, it can be inferred that diversity’s potential can be used as an enhancement factor for the pedagogics in renewable energy education.

From the discussion, it was seen that the cooperation between students coming from developing and developed countries can have an important impact on the understanding on the variety of resources available to produce renewable energy and how they can be utilized to foster sustainable development. Additionally, the interaction between students with different levels of professional experience in distinct renewable energy fields enables knowledge exchange. Moreover, diverse opinions in a group of students with multidisciplinary academic backgrounds can lead to better results in tasks and projects imparted during the lectures.

A diverse structure in the study programme can widen the options for the students’ career paths. A mix of theoretical and practical training builds a baseline knowledge to be used in the students’ field of interest.

Furthermore, it can also be inferred that diversity is the result of every student being authentic. Each student is unique and the programme uses this uniqueness to foster a higher quality education regarding renewable energies. The atmosphere in the lectures, built with the diversity of its participants, allows free communication of ideas, experiences and points of view, at all times with respectful regard for differences in, e.g. culture, religion, politics, etc. Values such as gender equality can also be promoted during the lectures and is implemented in the criteria for participant group selection in the programme.

All the previously mentioned aspects facilitate the learning process and enhance students’ skills such as language proficiency, teamwork in a multicultural environment, self-confidence and a critical view towards stereotypes, which accompany the professional and personal lives of the participants in the programme.
References

Current and former students (from PPRE, other programmes, and the Jade University in Oldenburg) participating in PPRE lectures, 2016. Results from the survey about diversity in PPRE (2016).


Flexible and individually adaptable online education on Renewable Energy – the REO Master’s Programme

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Abstract
In recent years, there is an increasing demand for flexible, time- and location-independent academic study programmes. For this reason, blended-learning concepts have been and are being developed in many disciplines. Such programmes can be studied mainly online and part-time, from all over the world, supplemented by short on-campus periods. In the field of Renewable Energy education, the blended-learning master’s degree programme Renewable Energy Online is currently being developed at the University of Oldenburg, Germany. This article aims at presenting the concept of this programme. Thereby, it focuses on the flexible and individually adaptable approach which addresses a highly diverse target group including students from emerging and developing countries.

Key words: renewable energy education, online education, student-centred learning, diversity, internationalisation, competence orientation

1. Introduction

Limited resources, climate change and demand for access to modern and sustainable energy services are currently some of the most urgent and long-term global challenges. Renewable Energy technologies could provide an environmentally compatible, resource-saving, efficient, secure and affordable energy supply. However, for an increasing share of Renewable Energy in global energy production, a large number of qualified personnel with university level competences in Renewable Energy technologies is needed (IRENA, 2017). This implicates the demand for study programmes to qualify Renewable Energy experts with a broad spectrum of qualification profiles.
Simultaneously, the variety of individual life situations of students, such as job or family duties, are challenging to be combined with traditional university courses. Furthermore, increasing digitalisation and internationalisation are gaining more and more importance in higher education (Kritz, 2012; Bischof & von Stuckrad, 2013). Therefore, an increasing demand for online or blended-learning higher education programmes can be expected.
Based on these developments and requirements, the blended-learning master’s degree programme ‘Renewable Energy Online’ (REO) is being developed at the University of Oldenburg within the framework of the project ‘mint.online’, funded by the German Federal Research Ministry (BMBF). The development of the curriculum and the instructional design draw on experiences from face-to-face master’s degree courses at the University of Oldenburg (‘Postgraduate Programme Renewable Energy’ and ‘European Master in Renewable Energy’). In the following, the programme concept and curriculum is presented, emphasising the flexibility and adaptability of the course for diverse needs and interests of international students.
2. The Renewable Energy Online Programme

The REO programme is developed as an English-language, technically oriented master’s degree course for natural scientists and engineers with a first university degree and at least one year of professional experience. It aims for qualification of international Renewable Energy experts with qualification profiles ranging from design of wind energy turbines to implementation of photovoltaic systems in rural areas to provide access to electricity. This implies not only the transfer of knowledge, but especially the development of subject-specific, methodical, personal and social competences on the student’s side. Prospective employers for graduates are e.g. companies, governments, research institutes and universities or development cooperation organisations.

The programme comprises 120 ECTS of part-time and mainly online study, including two on-campus periods. It covers theory as well as application of Renewable Energy systems, including areas such as energy conversion processes, wind energy, solar energy, energy storage, grid integration, sustainability or social aspects.

2.1 Curriculum

The study programme contains eleven mandatory and eight elective modules. An exemplary study plan is illustrated in Figure 1, assuming a standard period of study and consisting of all mandatory as well as four elective modules. The electives are specialisation modules with a focus on either technology, systems or social sciences. Students have to choose at least one module of each of these three fields.

The first semester serves the purpose to ease the transition into academic studies at a university. The module ‘Renewable Energy Basics’ provides the students with the necessary fundamentals for the following semesters. The module ‘Renewable Energy Laboratories & Excursion’ contains the first on-campus period of two weeks in Oldenburg. During this time, students have the opportunity to get to know their class mates and teachers. In a laboratory, they gain first hands-on experiences on basic Renewable Energy technologies as well as insights into measurement methods and strategies. The on-campus period also contains an excursion to Renewable Energy companies and plants. In a third module, further technical basics and applications of biomass, hydro power and solar thermal energy will be covered in the module ‘Selected Technologies of Renewable Energy’.

The second semester provides the necessary theoretical fundamentals for the later specialisations. The students have to choose three out of five mandatory modules, the remaining two have to be studied in the fourth semester. The modules are ‘Wind Energy Fundamentals & Wind Farm Design’, ‘Basics of Photovoltaics’, ‘Secondary Batteries’, ‘Renewable Energy and Sustainability’, as well as ‘Energy Resources and Conversion’.

The specialisation modules follow in the third semester and aim to convey more thorough competences and expanded concepts to various technological, system-related and social topics. The following electives are available in the technology category: ‘Design of Wind Turbines’, ‘Fluid Dynamics’, ‘Computational Fluid Dynamics’, ‘Solar Resource and Systems’ as well as ‘Storage Integration and Applications’. The electives ‘Grid Integration of Renewable Energy’ and ‘Off-Grid Electrification Project’ are provided for the system category. The module ‘Energy and Society’ deepens social aspects of the implementation of Renewable Energy technologies. In total, students elect four out of currently eight available specialisation modules, from which they study three in the third semester and the fourth one in the fifth semester. More elective modules are currently under development and will be added to the curriculum in the future.
The fourth semester contains the two remaining mandatory modules as well as the second two-week on-campus period. This includes the laboratory courses of the module ‘Simulation and Laboratory’ where the students focus on one Renewable Energy technology. Furthermore, a student conference is planned as well as another excursion to various Renewable Energy companies. Additionally, the students will also be prepared for the coming master thesis. In the fifth semester, an internship will take place at a Renewable Energy company, a research institute respectively a governmental or non-governmental organisation, accompanied by an online seminar. Professional experience can be accredited for this module. The concluding master thesis module will take place in part-time during the sixth and seventh semester. Students work mostly independently on a scientific task under the supervision of a professor or research fellow in order to compose their master thesis, improving and demonstrating their ability to work scientifically. Overall, the curriculum conveys a broad understanding of Renewable Energy systems, particular technologies, resources as well as sustainability and social implications.

2.2. Flexible, individually adaptable and student-centred approach

The REO programme addresses an international and interdisciplinary target group, including students from developing and emerging countries. This implicates a high degree of diversity concerning educational and professional background, learning culture and learning needs. Furthermore, interests in course contents as well as aspired competences regarding individual career objectives are expected to be heterogeneous. At the same time, the personal life situations of the students such as involvement in family or job duties will presumably cover a broad...
spectrum. This heterogeneity of the target group can be seen as a chance for the students and teachers but means also a challenge for teaching and learning. Therefore, a flexible, individually adaptable and student-centred study programme is required. In the REO concept, this approach is implemented in several components.

Firstly, the modular and part-time course structure can be adapted flexibly to individual life situations of students depending on their available capacity. Mostly time and location independent online work phases allow for a combination of the studies with family and job duties. Without having to stay abroad for several years, the students still get the chance to experience an international interdisciplinary learning environment, integrated in a large Renewable Energy experts’ network.

To address the diverse educational backgrounds, learning cultures and learning needs, close supervision and support of students is provided by mentors and lecturers via the online learning platform ‘C3LLO’. This platform has been developed by the ‘Center for Lifelong Learning’ (C3L) at the University of Oldenburg (Arnold, et al., 2016). It allows for uploading lecture material and teaching videos, setting up exercises and quizzes, conducting group work on shared documents, via video conferences or in group forums. In particular, it provides features for self-evaluation during self-study phases as well as functions to support individual learning processes of students by lecturer’s and mentor’s feedback. These forms of formative assessment give the students the possibility to observe their learning advancement and to adjust their learning strategies in a self-responsible way. This will ultimately motivate them to learn and pursue their learning objectives (McTighe & O’Connor, 2005). Reducing frustrating obstacles by applying formative assessments at an early stage of the learning process might be especially important for students with a lower level of prior knowledge and previously gained competences.

The diverse needs of the participants due to different educational and professional backgrounds, learning cultures as well as disciplines are addressed especially in the first semester of the programme, which aims at facilitating the transition from a professional life (back) into an academic study programme. Especially in the module ‘Renewable Energy Basics’, the students can complement their knowledge and competences in an individual and self-regulated way. This is realised by ‘primers’ which are short scripts and supplementary exercises about various relevant topics regarding Renewable Energy, such as mathematics, thermodynamics or electrical power systems. From a selection of these primers, the students can choose the topics in which they see their individual backlog demand. Communication with colleagues, mentors and lecturers via forums, webinars and individual emails as well during the on-campus period will support them to catch up on these topics. On the other hand, achievements from previous studies or extra-university activities could be accounted as credit points for the REO programme.

The diversity of the students concerning their interests, aims and motivations is addressed by the modularity of the curriculum and the various elective modules. The programme contains for example the electives ‘Grid Integration of Renewable Energy’ and ‘Off-Grid Electrification Project’ which either focus on grid integration mainly in developed and emerging countries or on access to electricity in developing countries.

Different interests, learning cultures as well as educational backgrounds are furthermore considered by certain learning and teaching methods such as problem-, project- or research-based learning. In group work on real-life projects or small research projects, the students can follow their own interests and apply their individual learning strategies in a self-regulated manner. Thereby, they develop manifold subject-related as well as methodical, personal and social competences.

Problem- and project-based learning is implemented in the REO programme e.g. in the modules ‘Off-Grid Electrification Project’ and ‘Secondary Batteries’, in which the students collaborate
in interdisciplinary teams via the online learning platform (Arnold, et al., 2016). In a self-organised way and based on their prior knowledge, they define, analyse, further investigate and eventually solve problems of real-life projects and finally synthesize present their results (Schmidt, 1983). Thereby, mentors and experts from the projects fulfil more the role of process facilitators than of lecturers.

Research-based learning is on the one hand enabled by the close connection of the REO programme to research groups at the University of Oldenburg and other research institutions. On the other hand, this methodical setting is integrated into the module ‘Simulation and Laboratory’ of the fourth semester. In this module, the students work online in groups on own research questions regarding certain pre-defined topics. Furthermore, they do independent literature research and simulation work as a preparation for their on-campus period. During their stay in Oldenburg, they set up and perform experiments, analyze and evaluate data. Subsequently, the results will be discussed and presented in form of a research paper. In this concept the students experience the complete procedure of a research project (Reinmann, 2009) – on a small scale, but flexibly adaptable to their individual interests.

Further characteristics of diversity such as gender, age, nationality or cultural background are treated in an open and sensitive way in the framework of the programme. They are explicitly made a subject of discussion in several learning units as well as addressed by individual counselling and supervision by mentors and lecturers (Behrend & Holtorf, to be published).

3. Conclusion

In summary, the REO programme addresses the diverse needs and interests of a highly heterogeneous audience by a flexible and individually adaptable approach. The concept includes a modular curriculum covering a broad spectrum of relevant Renewable Energy topics with the possibility to follow individual interests by selecting certain elective modules. Furthermore, the online-based format of the course allows for time and location independent part-time studying. The first semester facilitates the transition into the academic environment by appropriately designed modules. Individual needs and interests are addressed by student-centred learning and teaching methods as well as formative assessment features. Overall, the programme aims for a highly competence-oriented approach supporting the development of subject-related, methodical, personal as well as social competences on the student’s side.

After implementation of the programme, continuous evaluation will be conducted in order to further develop and improve the curriculum as well as the instructional design.

References


Designing Master Level Programmes in Renewable Energy: Trends and Trade-offs

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Abstract
This paper aims at presenting a discussion on some of the important issues that, to a large extent, affect the efficacy and efficiency of teaching/training programme offered at master level in the field of renewable energy. The paper briefly summarizes the findings of a desk-top review of the existing programmes in the field of renewable energy and other directly relevant areas that include (a) primary focus of the programme (renewable energy source(s), technologies, socio-economics and project appraisal, financing, policy and planning, sales and marketing etc.) and extent of internalization of remaining aspects, job profiles and potential employment opportunities targeted, relevance for local, regional or global audience, (b) duration of the programme and earned credit requirement for the award of degree, (c) share of core and elective components, specialization options, (d) industry interaction within the programme structure, (e) student intake - allowable heterogeneity in the academic and professional backgrounds of the students, expected level of preparedness prior to admission, linking admission requirements with the focus of the programme, (f) share of laboratory and/or hands-on skills training, research project, (g) self-study expectations from the student, (h) synergy with energy efficiency and climate change related aspects, (i) process of admission - aptitude/entrance test, academic performance and prior exposure and experience in the relevant field(s), language proficiency test, interviews, recommendations, statement of purpose etc., and (j) modalities of programme delivery and performance evaluation

Key words: Renewable energy education, master level programmes, curriculum development

1. Introduction

With a rapid growth of renewable energy sector, a large variety of employment opportunities are expected to be created that include researchers, engineers for design, fabrication, manufacture and installation, sales and marketing professionals, project appraisal and financing specialists, policy makers, technicians and mechanics etc. besides capacity building professionals. For several of the above-mentioned job opportunities, professional education and training at master level is of direct relevance. In cognizance of the same, a large number of master level programmes in the field of renewable energy have been offered in many countries of the world during last four decades. Owing to a variety of contributing and causal factors the programmes being offered have wide variations in their characteristics with specific strengths and challenges.
Preliminary results of an ongoing attempt to briefly summarize the underlying trends and associated trade-offs in designing and implementing renewable energy education and training at master level are presented in this paper.

2. Master Level Programmes in Renewable Energy Education

Efforts to offer university level programmes in the area of renewable energy were initiated in some countries after the first oil crisis in 1973 and gradually with increasing global importance of energy security and environmental sustainability a larger number of academic programmes have been offered. Postgraduate level teaching/training programmes have, so far, been prioritized as compared to full-fledged undergraduate level programmes in this area. A large number of postgraduate level teaching/training programmes that focus on renewable energy resources and technologies have been offered in the past and majority of them continue to be offered. Some of the important features of existing master level academic programmes on renewable energy level are briefly presented in the following paragraphs (The material is compiled on the basis of a desktop study of various master level programmes offered around the globe and no specific references have been cited for the same):

Primary focus of the Programmes

A large number of master level programmes are now framed exclusively around renewable energy sources and technologies. Relatively a much smaller number of master level programmes focus on economics, financing, business development, policy, regulatory and legal aspects of harnessing renewable sources of energy. In recent years, the Master in Business Administration programmes in Energy Management have also introduced renewable energy in their curricula. The scope and contents of the master level programmes offered often appear to have been guided more by the available expertise and research interests of the faculty as compared to the competencies (knowledge and skills) required for large scale development and deployment of renewable energy technologies. In some cases this has adversely affected the employability of the students. In many cases, there is an urgent need to realign the programmes to the local needs and renewable energy harnessing potential. Master level courses are now being offered on highly specialized subjects also such as (i) ‘Offshore Renewable Energy’ (ii) ‘Fuel Cells and Hydrogen Technology’, (iii) ‘Carbon Management’, (iv) MBA in Green Energy and Sustainable Businesses, and (v) Clean Energy Engineering etc. On the other hand, in some of the programmes the courses on renewable energy are supplemented by courses on energy – environment interaction, energy conservation, sustainable development and appropriate technologies etc.

Programme Structure

Well established master level programmes on renewable energy divide the same into Core and Elective course components (with the research project often being a Core component and sometimes even industry internship being also mandated). While the core courses are mandatory for all students enrolled for a programme, the students have some flexibility in selecting elective
courses out of a pre-defined basket. Depending upon the interest, prior exposure and future plans, the students make their choice of elective courses. Significant variation is observed in the core component of the master level programmes on renewable energy perhaps due to local and/or regional relevance as well as due to the expertise of the teachers involved. Possibility of allowing specialization options with suitable choices of core and elective courses have also been explored.

*Duration of the Programmes*

The minimum duration of full time postgraduate programmes varies from one year to two year. The earned credit requirement also varies accordingly. Most of the master level programmes have a strong research project component with some of the institutions necessitating an industry relevant (and sponsored) topic for the project work. Some institutions also have the provision of enrolling working professionals. Such part time students take longer to complete the course requirements.

*Industry Interaction within the Programme Structure*

A sharp difference is usually observed in this respect between the master level programmes offered in developing and developed countries. Most of the programmes offered in developed countries in North America, Europe and Australia often lay emphasis on the research projects being industry relevant and preferably sponsored by the industry. Moreover, experts from the industry participate in the programme delivery as well. In some of these programmes, Industrial internship is also encouraged as an integral component in the curricula. Majority of the programmes offered in developing countries are yet to prioritize active industry interaction in programme delivery as well as in providing avenues to the students for undertaking industry relevant studies.

*Student Intake*

A wide variation is observed in the academic and professional backgrounds of students eligible for admission into master level programmes on renewable energy. In general, there is considerable heterogeneity in this respect amongst the students admitted in a particular programme. Usually students with bachelor degrees in conventional engineering disciplines and also from physical sciences are eligible for admission into master level programmes on renewable energy. Usually there are no other pre-requisites for seeking admission into master level programmes. Aptitude for contributing to the field and basic preparedness to cope with the courses offered under the programme are usually not assessed prior to admission. Owing to an intake of students that is often highly heterogeneous for majority of the master level programmes with focus on renewable energy, there is often a need for bridge courses or alternatively the course delivery is paced to take all students along. Some institutions also require valid acceptable score of an English Language Proficiency Test
Laboratory and Other Components for Hands-on Skills Training

Majority of the master level programmes dealing with renewable energy resources and technologies have one laboratory course. However, the details of the experiments offered and evaluation modalities for the same are not available in the literature. In fact, on a broader basis, there is an urgent need to strengthen the experimental and hand-on skills training component of the master level programmes on renewable energy, particularly in developing countries. The laboratory experiments as well as the hands-on activities should directly relate to the practical knowledge and skills needed by the potential employers of the student after successful completion of the degree requirements.

Self-Study Expectations from the Students

At master’s level, in majority of the universities and institutions, the students are expected to be groomed for self-study as well. With explicitly defined learning outcomes (and also the share of each of the learning outcomes in performance evaluation) for each of the courses offered under the master level programme, the students are expected to supplement the classroom learning with their self-study efforts so as to satisfy the objectives of the course.

Synergy with Climate Change and Energy Efficiency Aspects

One of the primary reasons for a global emphasis on large scale development and deployment renewable energy technologies is the concern for environmental sustainability and the risk of climate change due to anthropogenic emissions from the energy sector. At the same time, there is substantial scope for adoption of energy efficiency measures and achieve significant reduction in the energy intensity of goods produced and services provided in an economy. Thus, in a substantial fraction of master level programmes on renewable energy there has been an explicit trend of including courses on energy conservation, energy efficiency improvement, energy environment interaction, climate change etc. This is expected to enable students enrolled in master level programmes to understand potential implications of improvements in efficiency of energy utilization and also of climate change concerns for the renewable energy sector. For example, identification and exploitation of opportunities for waste heat recovery in an industry should go hand in hand with the assessment of solar energy utilization potential for meeting low temperature process heating demand in the industry. Similarly, stringent emission norms and regulations for various end use equipments are likely to increase adoption of renewable energy based supply options with suitable incentives offered for the same.

Modalities of Programme Delivery

Majority of the existing teaching/training programmes still necessitate class room contacts. However, in recent years, initiatives have also been taken towards offering distance mode / online programmes. Many programmes now offer both options (on-campus or online study) to the students to choose from. Online programmes offer the flexibility to study from home and also the
freedom to learn at one’s own pace (except for classes offered via live video or teleconferencing). Online programmes often make use of pre-recorded lectures or reading materials. To make sure that there is no compromise with the hands-on-training component of the study, the students undertaking online programmes also have to be present for specific classes or internship arrangements. The students often have the option to complete the courses individually or in an online group setting with peers and course teachers communicating through discussion boards. It is worth mentioning that some globally renowned institutions such as Stanford University and Massachusetts Institute of Technology offer online courses in the area of energy. Many more institutions may prefer to adopt this strategy in near future. In spite of several positive features of classroom contact mode of programme delivery, web based education may help achieve quality human resource development objective at much lower costs and well within reasonable time limits to achieve the objectives of economy and efficiency. It is worth mentioning that for on-line mode the students must have access to a computer with a high speed internet connection and also a printer to make copies of the study material. For courses that involve streaming of videos a computer with audio-video capabilities would be required.

Types of Inputs Provided and Expected Learning Outcomes

From an extensive review of the available course contents of a large number of master level programmes on renewable energy it is observed that the inputs provided to the students include (a) basic concepts, (b) detailed models for component/device and performance analysis and evaluation, and (c) one or more of the issues related to fabrication/manufacture including materials considerations, system design, testing, standardization, installation, operation and maintenance, techno-economic evaluation, financing, business development, environmental aspects etc. However, it is practically not feasible for a single master level programme to cover all the above-mentioned aspects for different types of renewable energy technologies. This, to some extent, explains the emerging trend of offering master level courses on individual renewable energy sources or even its sub-components.

As mentioned earlier, the laboratory (experimental) component of the curricula is apparently not being accorded the importance and priority it deserves in majority of the teaching programmes in renewable energy, particularly, in developing countries. It is a serious limitation of the programmes as mere treatment of theoretical aspects of topic without getting sufficient hands-on-skills experience with the hardware can prompt half-baked immature decisions or set wrong priorities for development and dissemination of renewable energy technologies. Rigorous hand-on-skills training and comprehensive inputs on hardware related aspects of relevant technologies must be provided as a part of any curricula on renewable energy technologies. For most of the renewable energy education programmes, particularly in developing countries, there is an urgent need to develop suitable laboratory, demonstration and do-it-yourself type activities.

Resource assessment is another important area that is often neglected in a majority of master level programmes. Similarly, techno-economics and financing of renewable energy technologies and business development related inputs are often not included in many of the existing teaching programmes. With a very large potential of decentralized household level use of renewable
energy technologies around the globe, it is also important to discuss socio-cultural issues associated with dissemination of renewable energy technologies.

Normally, a master’s degree in renewable energy is expected to provide students with the opportunity to develop specialized skills in design, development, deployment, operation and maintenance of renewable energy technologies. On a more broader level, a master level programme on successful completion, is expected to equip the students with adequate knowledge and skills for being able to effectively contribute towards sustainable energy supply initiatives and strategies. Often master level programmes with focus on renewable energy also cover economics, financing, policy and regulations, legal aspects etc. so that upon successful completion of the programme a student will be able to acquire the ability to provide appropriate sustainable energy solutions to the challenges presently being faced by the global community.

Academic department(s) involved

Energy being an interdisciplinary subject, several different academic departments have taken initiative towards offering teaching/training programmes on renewable energy at master level. These include the departments of mechanical engineering, chemical engineering, electrical engineering, physics, civil engineering, environmental engineering and architecture. In some academic institutions, exclusive academic units on energy also exist that offer programmes on renewable energy.

Prerequisites for the courses

Given the interdisciplinary nature of academic programmes in renewable energy and likelihood of students from different academic and professional backgrounds participating in the programmes, defining pre-requisites in terms of prior preparedness for undertaking a course is very important. However, a detailed review of the curricula of a large number of existing programmes indicates that adequate attention is often not being given to ensure that all essential prerequisites for each of the courses are explicitly defined. For example, for a course on solar thermal utilization the students should have the basic knowledge of heat transfer, thermodynamics, optics and calculus. It is also desirable that the student has successfully completed a broad course on various sources of energy (conventional as well as non-conventional) prior to studying any advanced course on a specific renewable energy technology.

3. Concluding Remarks

There has been a remarkable progress in terms of the numbers of and variety in the master level programmes being offered with focus on renewable energy. However, there are a large number of issues that should be carefully studied and accordingly the programmes modified so as to ensure effective and efficient role of master level programmes on renewable energy in contributing towards meeting increasing energy requirements of the society in a sustainable and economically feasible manner.

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Abstract

This paper presents a preliminary review of the existing teaching–learning resource materials for renewable energy education. The main features of existing resource materials and the aspects that need immediate attention and collaboration at global level are presented.

Key words: Renewable energy education, teaching-learning resource materials, Need for international cooperation

1. Introduction

Renewable energy education is still evolving as a formal discipline with ongoing changes in the scope, contents, mode of delivery and evaluation etc. and is being integrated with other aspects such as climate change, synergy with conventional energy supply, project development and appraisal etc. Moreover, the focus, emphasis and modalities of delivering renewable energy education programmes would have to be different for preparing manpower with different job responsibilities – researchers, engineers, appraisal and financing specialists, policy makers, technicians and mechanics etc. Teaching-learning resource materials are required to help the teachers as well as the students in achieving the envisaged learning objectives of a course. Since education and training in the field of renewable energy is still evolving, availability of appropriate teaching-learning resource materials that keep pace with the changing requirements besides satisfying perceived needs of each category of stakeholders is critically important.

A variety of different types of teaching-learning resources can be used that include text books, reference books, research monographs, laboratory manuals, teacher guides, self-appraisal modules, do-it-yourself kits, audio-visual aids, demonstration modules etc. The teaching–learning resource materials should ensure (a) scientific and technical accuracy (with factually correct information), (b) clarity of information and suitability for the level of intended audience, (c) affordability for all intended users/beneficiaries, (d) archival importance and wherever necessary, mechanism(s) for regular periodic revision. It is therefore necessary to review the present status of teaching-learning resources in the field of renewable energy and also identify areas that need additional efforts. Preliminary results of an ongoing initiative in this direction are being presented in this paper.
2. Present Status

As expected, only after the first oil crisis of 1973, with the formal educational programmes on renewable energy being started, attempts were made to prepare teaching-learning resource materials on renewable energy. In fact, in the initial phase, the availability of learning resources encouraged initiation of training and education activities in the corresponding areas. For example, due to the availability of the book entitled "Solar Energy Thermal Processes" by Duffie and Beckman as early as in the year 1974 and its subsequent revisions, courses predominantly dealing with solar thermal utilization are still one of the most commonly offered university level courses in the field of renewable energy.

Presently a reasonably large variety of renewable energy education and training programmes are being offered. The variation is in terms of the renewable energy sources (solar, wind, hydro, biomass, wave, tidal etc.) and different aspects (such as resource assessment, technologies for harnessing, economics, financing, project development, environmental impacts, policy, regulatory and legal aspects etc.) being covered. As a consequence, there is some variation in the type of resource materials that is presently available to the students and teachers. However, the preparation of appropriate teaching-learning resource materials for renewable energy education has not yet received the importance and attention it deserves. Good quality text books are not available even for courses commonly included in postgraduate level teaching/training programmes in the area of renewable energy that has apparently received maximum attention.

There are some books on resource assessment and technology components of solar thermal and photovoltaic utilization, wind power and hydropower that may be considered as resource materials for education and training programmes at university level. There are a few books that can perhaps be used as text books for an introductory course on renewable energy. However, biomass energy is not in the same category in respect of resource material availability. Similarly, teaching-learning resources on economics, financing, project development, policy, regulatory and legal aspects of harnessing renewable sources of energy are not yet available. There is very little effort made towards developing appropriate resource materials for educational programmes aimed at preparing mechanics and technicians in the field of renewable energy. Teaching-learning resource materials for properly introducing renewable energy related concepts in the school curricula are also not available.

One of the commonly under-prioritized aspects in renewable energy education at all levels is the laboratory experiments and other hands-on skills training components. There is almost negligible effort towards developing laboratory manuals for offering experiments, do-it-yourself booklets, replicable demonstration sets, etc. for promoting the same.

Another important observation relates to the apparent lack of distinction between teaching-learning resources being targeted for students engaged in research work, undertaking master level projects or those studying an introductory course. As a consequence there is no conscious effort towards maintaining consistency and continuity in the resource materials presently available to students at different levels of their engagement in the field of renewable energy.

Only a small fraction of the books on renewable energy have so far had multiple editions. This may be attributed to (i) rapid evolution in the field, (ii) lack of incentive(s) to revise and/or update and (iii) speculative authors.
Majority of the available resource materials do not present a holistic treatment of topics perhaps due to the field being interdisciplinary and consequently the inability of author(s) to do justice with all facets. Another related problem pertains to the tendency of the author(s) to cover the topics within their expertise in much more detail than justified (or needed at a specific level of an educational programme).

Most of the well known teaching – learning resources are available in English language. This is an additional challenge for education and training programmes being offered in other languages. Modalities of making authentic and useable translations available are almost non-existent in the field of renewable energy.

To complicate the challenges due to above-mentioned inadequacy of teaching-learning resource materials for imparting renewable energy education at all levels, further there is a vast difference between developing and developed countries in this regard. A substantial fraction of the resource materials those are available in developed countries may not be available in the developing countries. Moreover, since most of the currently available resource materials essentially originate in developed countries, their cost in developing countries is often beyond the affordability of the potential users.

Though there has been substantial progress in making e-journals available to doctoral, master level and other students as well teachers, the cost is prohibitively high for most of the academic and research institutions in developing countries. The availability and acceptance of e-books is also slowly gaining momentum in some areas.

3. Desirable Features and Proposed Measures

Important features that are expected of any teaching - learning resource materials envisaged to be used for imparting renewable energy education are briefly described in the following paragraphs and the same should preferably be taken into account in deciding any collaborative activities in this direction. The material presented is essentially based on Kandpal and Broman (2014 and 2016).

**Variety and Flexibility**

Renewable energy education and training has to be imparted at several levels. Suitable teaching-learning resource materials should be made available for each level of renewable energy education – from school to university level formal and informal programmes. One of the options is to prepare separate sets of teaching - learning resource materials for each level of renewable energy education. Alternatively, to the extent possible, the teaching - learning materials may be prepared with inherent flexibility to facilitate their use at different levels of renewable energy education. For example, the possibility of using the same book on solar energy for offering introductory courses to university level students and also to technicians and mechanics may also be assessed. The respective teachers should be able to select appropriate inputs without compromising with the efficiency and effectiveness of the teaching/training programmes. Of course, such a flexibility is relatively more easily possible with electronic audio-visual resource materials where one can have a choice of selecting the text (description) being given along with a figure/photograph, the language spoken and problems to be solved etc.
Periodic revision of teaching - learning resource materials

The teaching - learning resource materials must be revised at periodic intervals to keep pace with the latest advancements in the emerging field of renewable energy. An efficient functional mechanism for obtaining feedback from all stakeholders on the available teaching – learning resource materials for renewable energy education should be established. The feedback can be taken into account during revision of existing resource material as well as in developing new resource materials.

Developing suitable mix of teaching - learning resource materials

In view of quite diverse characteristics of teaching - learning situations/strategies in different countries/institutions it may be necessary to promote a multi-pronged approach in the development of teaching - learning resource materials for renewable energy education. Printed books/manuals etc. should be supplemented by web-based course module software as well as audio-visual options.

One of the important decisions is regarding the suitability of introducing/including renewable energy related topics in the standard learning resources (such as text books of engineering and sciences) or to prepare separate resources exclusively on the same. For example, whether to prepare a separate book on use of alternate fuels in internal combustion engines or include a few chapters dealing with specific features of alternate fuel use in a book on internal combustion engines. Similarly, whether to have a separate book on improved biomass cook-stoves or include the relevant material in a book on combustion. Many other such examples can be given (such as heat transfer in solar collectors, energy efficient motors, waste heat recovery, passive solar buildings etc.) that can be treated in these two approaches.

Motivating authors towards preparation of teaching - learning resources materials

With relatively very small number of students currently engaged in renewable energy education as compared to conventional science and engineering disciplines, it may not be monetarily rewarding for publishers to be involved in the development of teaching-learning resource materials. It may therefore be necessary to support preparation of teaching - learning resource materials on renewable energy to motivate competent authors to contribute to this cause. Preparation of quality teaching - learning resource materials requires commitment and dedication from experienced teachers and the same should be duly compensated and rewarded.

Experience sharing and information exchange

All the stakeholders involved in furthering the cause of renewable energy education would certainly benefit from the availability of efficient mechanisms(s) for experience sharing and information exchange on the availability usefulness, limitations etc. of the existing teaching - learning resource materials. Information on printed materials as well as web- based resources should be freely available for further affirmative action and use. There is an urgent need to establish and strengthen global cooperation in this direction.
Low price versions of the teaching - learning resource materials

To facilitate human resource development in the field of renewable energy in developing countries at a scale that would match their increasing requirements, it is necessary that good quality teaching - learning resource materials are made available at prices affordable by the teachers and students in these countries. It may therefore be necessary to subsidize the production and distribution of the relevant resource materials in the initial phase of the human resource development initiatives in developing countries. Similarly, availability of free-to-download materials would be of great help for both learners and educators. Availability of software such as SAM, RETScreen, HOMER etc. are examples of excellent initiatives in this direction.

Use of modern techniques of communication and information processing

There is a growing need to make use of modern techniques of communication and information processing in the development of teaching - learning resource materials on renewable energy. Electronic communication techniques facilitate (i) very high storage capacity in small space, (ii) very fast information transmission, (iii) almost instantaneous connectivity of one stakeholder with other stakeholder (s) for experience sharing, information exchange etc., and (iv) development of stimulation model (s) for better interaction between teacher and the learner in a variety of situations.

4. Concluding Remarks

There is an urgent need to consolidate and prepare a database of existing information and material on teaching –learning resources for renewable energy education. The same could be made available to all stakeholders across the globe. There is a need to identify and motivate competent authors willing to contribute in a time bound manner to the cause of making good quality teaching –learning resource materials available at reasonable price.

Large scale availability of print as well as e-versions of quality teaching – learning resource materials with the price decided on no profit-no loss basis would go a long way in improving the quality of renewable energy education being imparted. Attempt can be made to find donors to support such an initiative. In order to facilitate availability of quality learning resource materials in developing countries, permission may be sought to locally reprint select suitable material available in the developed countries.

Global cooperation in this regard is expected to be of great help and effort needs to be made in that direction. For example, the possibility of reviving the International Association for Solar Energy Education (IASEE) could be revived with resolving the challenges in making quality resource materials for renewable energy education available at affordable prices as one of its important mandates. The International Renewable Energy Agency may further expand its activities in this direction. The following issues need to be carefully analyzed and debated towards developing collaborative initiatives for preparation and provision of appropriate teaching learning materials in the field of renewable energy:
(a) The trade-off between print and e-version of learning resource materials particularly for countries where establishment of suitable infrastructure for desired level of e-connectivity may take longer than the urgency of renewable energy education necessitates.

(b) Reducing the cost of teaching-learning resource materials for all stakeholders

(c) Continuity and consistency between teaching-learning resources material targeting different levels of renewable energy education initiatives

(d) Potential modalities of expanding and strengthening global cooperation in preparation of high quality teaching-learning resource materials and in ensuring access to the same to all stakeholders across the globe (including arranging funds for the same)

(e) Facilitating preparation (including translation of well known existing resource materials) of learning resource materials in local languages - particularly for introducing renewable energy at school level

References


Dealing with winner's history in RES-T education

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Abstract
Renewable energy utilization in transportation applications (RES-T) belongs to the key fields of climate change mitigation. RES-T education is needed for evading climate crisis, but it faces serious obstacles. Winner’s history bias is one of the most difficult educational problems requiring immediate attention. Description of the overall educational challenge and winner’s history as a special example is covered in two parts. 1) The paper at hand gives an introduction and discusses this field in a rather broad perspective, including some theoretical framework. 2) The conference presentation focuses on practical examples.

Key words: RES-T, renewable energy, transportation, education, winner’s history, climate change

1. Introduction

Renewable Energy Sources in Transportation (RES-T) covers only 3 % of global transportation energy demand. As a comparison, renewables have well over 20 % share of global energy demand in electricity (RES-E) and thermal energy (RES-H/C) sectors. Only 4 % of global renewable energy supply is consumed in the transportation sector. (IEA 2016)

Despite continuously increasing political efforts to address environmental problems originating from fossil fuels, progress in the transportation sector has been very slow. Shortcomings in both general education and professional technical education have contributed to this failure. It is usually not recognized in relevant educational curriculums that all transport modes were originally RES-T powered and RES-T technologies have always been utilized in varying degrees, also today. The relevant educational curriculums also tend to ignore both technological and environmental advantages offered by RES-T, in comparison with current conventional transportation technologies.

The resulting lack of awareness has detrimental effects in policies combating climate change and other environmental problems caused by fossil fuel consumption. Ignoring the opportunities offered by RES-T technologies bears ominous resemblance to the aircraft accident type called Controlled Flight Into Terrain (CFIT). In 2010-2014 it was the second largest fatal aircraft accident category globally, and the most severe type of accident, as 91 % of these accidents involved fatalities (IATA 2015). It is an accident, where a functional aircraft crashes unintentionally by pilot control. It is caused by the loss of situational awareness, which means fixation into non-essentials and ignoring essentials. In all these accidents multiple warnings have been given to the pilots by the aircraft electronics and almost always also by crew members. In the analogous case of climate change control, the threat became clear to physicists in the 1960s: they submitted a request for immediate problem solving action to the United Nations, which took the issue in its agenda in 1970 (Weart 1997). Since the first UN environmental summit in 1972, the pilots of the Earth have received warnings with increasing severity, but situational awareness still has not been achieved. Fixation into fossil fuels blocks warnings and prevents application of correct controls to avert the impending catastrophe.
2. The educational challenge

This chapter is devoted to description of the underlying educational challenge. Traffic lights with colours having well established familiar meanings are applied here as educational tools (Fig. 1).

All kind of decision making processes – including aircraft control, steering climate policies and choosing next car based on energy sources it is able to utilize – involve different types of inputs. Five basic input types are represented in Figure 1 by traffic lights. Green light (information) means correct input based on scientific method. Red lights mean incorrect inputs originating from honest misunderstandings (misinformation) or purposefully created incorrect information (disinformation). Both green and red lights represent inputs based on physical reality, whether they are right or wrong. Therefore, all of them include “information” in their labels. Yellow lights represent inputs that are not explicitly tied to physical reality. Unconscious inputs are actions, e.g. hand or foot control, generated directly by visual and other sensory signals, without mental processing between them. Free thought means inputs generated by mental processes with insufficient data basis. Yellow colour is used here, because both of these input types may produce correct, incorrect or neutral (no impact) decisions.

The ability to choose green inputs, reject red inputs and govern yellow inputs in decision making processes is a skill, which in complicated issues need to be refined by educational curriculums. The airline industry and administration combat the CFIT problem by CRM (Crew Resource Management). It is an educational curriculum for increasing the awareness of the whole crew and for establishing communication protocols to enable swift delivery of crucial information to pilots from all crew members, and via cabin crew also from passengers. This addresses governance of the yellow inputs, which may prevent green inputs from reaching pilot attention. It is a more subtle issue than handling the red inputs, which in the case of aircraft mean technical malfunctions (misinformation) and sabotage (disinformation).
Climate change related decision making still suffers from overwhelming burden of red and yellow inputs in all levels: from households to companies and organizations, and from subnational to national and global administrations. The climate change crisis can be solved, if attention is focused on this educational core problem. The ozone layer crisis provides a valuable lesson and encouragement. Removal of the red inputs was required to solve the problem, and it was achieved by superb educational interventions (Christie 2001).

This paper focuses on transportation, because among the climate change mitigation policy sectors it is especially vulnerable to red inputs, as slow progress demonstrates. Two examples are given, both of which concern replacement of conventional fossil fuel technologies by RES-T technologies. An example called “winner’s history” is the main theme, but to make sure it can not be considered an isolated case, another example is given first. It concerns the abuse of energy efficiency, which has proven a seductive way to misdirect attention (Fig. 2).

![Figure 2. Locating the energy efficiency abuse problem: Lifecycle (WTW = Well-to-Wheel) greenhouse gas emissions and energy consumption of selected fossil and renewable fuels in transport.\(^1\)](image)

All biofuels have higher lifecycle energy consumption than conventional fossil fuels, as the horizontal axis in Figure 2 shows. Nature has refined liquid and gaseous primary fossil resources to a level, where little additional energy is needed for bringing them to market. Inherent technical reasons prevent biofuels from competing in this aspect. But biofuels offer very large cuts in lifecycle greenhouse gas emissions, as the vertical axis in Figure 2 shows. It means that increase of energy consumption is required for reduction of greenhouse gas emissions. This is counter-intuitive like the notions of round Earth, rotation of Earth around Sun and the innocence of Sun regarding climate change. Therefore, yellow inputs tend to align in favour of crude oil dependency in educational regimes where RES-T education is absent, i.e. green inputs are weak. Red inputs would hardly be needed, but in this case they shine at especially strong intensity. Industrial disinformation

\(^1\) This illustration by Lampinen (2015, 42) is mostly based on data produced and published by the Joint Research Center of the European Commission for an average car. Plant and beef diet values represent walking in extreme cases. They have been calculated from carbon footprint data of supermarket products. Plant and beef diet represent walking; the rest represent ranges for an average car powered by an internal combustion engine.
suggests that energy efficiency is the main environmental indicator, although it actually is not an environmental indicator at all. Environmental indicators (such as emissions) measure environmental impacts, whereas energy efficiency is a background factor. Whether energy efficiency increases or decreases, environmental impacts may increase or decrease. The energy efficiency misconception has infiltrated into administrations, strategies, legislation, education and many types of organizations, where expertise is sought. They provide misinformation at blinding intensity and act as the last line of defence of crude oil dependency. Strengthening green inputs by RES-T education at all levels is required for recovering this seductive trap.

3. Winner’s history bias

A bias called “winner’s history” is responsible for some of the red and yellow inputs described in Chapter 2, especially within the transportation sector. The original meaning of this concept is the historiographical problem generated when history is written by winners of wars. Similar issues are found in economic history, which covers development of transportation. Surviving companies tell histories from their perspectives, with natural tendencies to omit predecessors and rivals. Professional inclusion of wide variety of historical records and inherent attention into selection bias phenomenon make sure that company histories are not the core of scholarly accounts of history of technology. But history of technology written for the general public is often based on lighter and easier accessible sources, like company histories. Therefore, winner’s history problem can be identified e.g. in school books and museums, although scientific method based information in academic literature covering the same issues does not support it (Fig. 3).

Winner’s history bias influences negatively public awareness of RES-T. Recognition of the role RES-T technologies have played in development of modern transportation is one key aspect requiring attention within the educational challenge discussed in Chapter 2. Losing track of past development inhibits proper planning of future development from domestic to municipal, national and international levels. Although contributions from renewable energy sources and technologies are sometimes ignored in any transport mode, gravity of the problem is small in many of them (Table 1). Winner’s history bias is a common denominator of the two transport modes experiencing severe problems: motorized road transport and air transport. Having impact on motorized road transport, the winner’s history bias generates widespread misunderstandings for the general public and technology professionals. This mode of transport has dominating share of energy consumption in transportation, and it is a part of everyday life for all. Unlike in other transport modes, everybody have power to influence energy choices in motorised road transport.
Table 1. Educational problem of understanding the role of RES-T technologies.

<table>
<thead>
<tr>
<th>Gravity of the problem</th>
<th>Transport modes</th>
<th>Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very small</td>
<td>Light land transport</td>
<td>- Known from general history, no inventors</td>
</tr>
<tr>
<td></td>
<td>Water transport</td>
<td>- Wide-spread historical and current use</td>
</tr>
<tr>
<td>Small</td>
<td>Rail transport</td>
<td>- Known from general history</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Wide-spread historical and current use</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Off-road, underwater, pipeline and underground transport</td>
<td>- Inadequate attention in general</td>
</tr>
<tr>
<td>Large</td>
<td>Space and planetary transport</td>
<td>- Primary energy sources ignored</td>
</tr>
<tr>
<td>Severe</td>
<td>Motorized road transport</td>
<td>- Winner’s history bias + everyday experiences =&gt; misinformation</td>
</tr>
</tbody>
</table>

The winner’s history bias is revealed in its clearest form by misplaced credits given to inventors and vehicles. Outstanding examples are the Daimler motorcycle from 1885, the Benz car from 1886 and the Wright aeroplane from 1903. They are commonly miscredited as the first motorcycle, car and aeroplane (Lampinen 2011). Unlike their predecessors, all of them are gasoline powered and manufactured by surviving companies (Table 2). These are especially striking cases, because several earlier vehicles of each type have survived and can be viewed at some of the most prominent museums of the world.

Table 2. Background of misplaced first innovation credits for 3 vehicle types.²

<table>
<thead>
<tr>
<th>Vehicle survived?</th>
<th>Motorcycle: Daimler 1885</th>
<th>Car: Benz 1886</th>
<th>Aeroplane: Wrights 1903</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No, No</td>
<td>No, No, No</td>
<td>No, No, No</td>
</tr>
<tr>
<td>First experimental?, commercial?, practical?</td>
<td>No, No, No</td>
<td>No, No, No</td>
<td>No, No, No</td>
</tr>
<tr>
<td>First ICE?</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>First gasoline powered?</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Company survived?</td>
<td>Yes</td>
<td>Yes</td>
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² More details of these 3 cases are given in the ISREE2017 presentation by the author.

It is of the utmost importance for RES-T education curriculum to include historical description on how crude oil took over fuel markets of the most common vehicle types in the early 20th century. It has become rather well known that electric and steam cars competed very well in the market with gasoline cars in the early 20th century and that political efforts contributed to yielding their market to gasoline cars (Kirsch 2000). However, this lesson has educational weaknesses as gasoline cars had reached significant technical and economic advantages in the 1910s over electric and steam cars. Better lesson is given by renewable internal combustion engine fuels, since they had both technical and economic advantages over gasoline. The story of ethanol gives the best clarity in this issue. Ethanol was not the first fuel in cars, motorcycles or aeroplanes (although it was the first spacecraft fuel), but it preceded gasoline in all these vehicle types, and it is still utilized in all of them. It had substantial economic advantage and superior technical properties at the time gasoline was introduced in the market. For example, Henry Ford utilized ethanol in his first experimental car, Ford Quadricycle, and also in the first mass-produced car, Ford Model T. However, successful political and industrial efforts managed to raise gasoline into dominating market position (Kovarik 1998).

Essential for understanding the winner’s history problem is that the loss to gasoline meant that ethanol was almost completely removed from automotive business histories, even those of the Ford Motor Company. This fate is shared by other renewable fuels, RES-E mobility and all other RES-T technologies, even though large amount of these technologies provided then and still possess today technical superiority over crude oil based mobility. One educationally illuminating example is car
racing. Gasoline (octane number 95-102) has disappeared from racing series that allow high performance fuels, such as methanol (octane number 107), ethanol (octane number 108) and biogas (octane number 140). Although professional high performance drivers do not choose gasoline unless rules force to do so (information base), layman drivers believe that gasoline is a high performance fuel (misinformation base).

4. Discussion

Alerting the United Nations in the 1960s of the impending climate crises was not done lightly by the physicists. This was analogous to alerting fire brigade of a house fire. It was known that fire was burning, human contribution for igniting it was significant, it had potential for complete annihilation, and it could not burn out by itself before total destruction. It was also known how to extinguish it. There was no need for further scientific or technical evolution before action. However, in this case the fire brigade has focused its efforts on studying the properties of the flame, estimating its possible paths of progress and developing new alternative methods for extinguishing it in case some day putting out the flame will be required.

Just like in the case of the ozone layer crises, technical solution to the climate change crises has been known as long as the scientific community has been aware of the problem. In both cases political decision making processes have suffered from distorted information inputs. The ozone layer crisis was overcome by successful educational interventions. Overcoming the climate change crisis is possible if educational interventions enhance accurate information and reject distorted inputs into decision processes in all levels from households to organizations, from local to national and international administrations. As the renewable energy transition has proceeded especially slowly in the transportation sector, main emphasis needs to be assigned to RES-T education.

The CRM curriculum was adopted by the air transportation authorities after large amount of functional aeroplanes had crashed unintentionally by pilot control. As there is only one Earth, piloting it through the climate crises requires adopting corresponding educational curriculum before the first and the only unintentional crash under pilot control takes place.

References

Education and training gaps in the renewable energy sector

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Abstract
One of the barriers to achieve the expected renewable energy market development is the shortage of qualified human skills. Global data on education and training on renewable energies was analysed in order to gain an understanding of the current education supply worldwide. Findings are: (i) the shortage is more acute in developing countries; (ii) there is a Mismatch between education system offer and industry demand; (iii) mismatch in the suitability of the curricula; (iv) students and educators are moving towards online training for collaborating and learning.
In addition to increasing, improving renewable energy education and training, attracting female workers to renewables will facilitate the reduction of scarcity of professionals in the sector.

Key words: renewable energy, education and training, gaps

1. Global status and forecast of employment in renewables
At the end of 2016 (IRENA, 2017), renewable energies employed, directly and indirectly, 9.8 million people worldwide. In terms of technologies, solar photovoltaics employed 3.1 million people, and liquid biofuels and wind power employed 1.7 million and 1.2 million people respectively. With reference to countries, China with 3.6 million, Brazil with 876 thousand and United States of America 777 thousand people, were the three countries leading the ranking of employment in renewables. In terms of the value chain (IRENA, 2011), the majority of employment is created in construction, installation, operation and maintenance. These are primarily local jobs that are spread well across countries, while manufacturing jobs, in particular in photovoltaic panels and wind turbines, are increasingly concentrated in Asia (IRENA, 2017). Renewable energy (RE) can sustain 24.4 million jobs worldwide by 2030 if the Sustainable Energy for All goals are achieved by 2030 (IRENA, 2016). One of the barriers to achieve the expected market development and job creation is the shortage of qualified human skills for the sector (Malamatenios, 2016), (IRENA, 2012).

2. Methodological approach
Research was conducted in three phases. In the initial phase, a literature review of academic papers and secondary sources on shortages of skills and education gaps in RE was carried out. In the second phase, a comprehensive analysis of the IRENA
Renewable Energy Learning Partnership database was performed in order to assess the current supply and demand of RE training and education worldwide. The IRENA Renewable Energy Learning Partnership (IRELP) is a project of the International Renewable Energy Agency (IRENA) aiming to increase access to and awareness of RE education and training opportunities. IRELP, from April 2012 to April 2017, offered access to five global databases of RE courses, internships, webinars, training guides and resources for educators. The IRELP course database gathered information on over 2,500 existing RE training opportunities offered around the world, including short-term vocational and professional development courses, apprenticeship programmes, and associate, bachelors, masters and doctorate programmes. The database was categorized by course type, topic, location, duration, language, and qualification awarded. Information within the database was gathered through IRENA desk research (70%), IRELP’s 22 partner organisations, including RE regional centres, industry associations and educational institutions (20%) and volunteer members of the IRELP Global Network (10%). Data that was sourced through partner organisations and volunteers was verified by IRENA prior to being made public through the IRELP web portal (IRENA, 2015).

In the final phase, a survey was designed and circulated to stakeholders working in the field of human resources and RE to discuss the result from the previous phases and gain a better understanding of the demand for RE skills and challenges faced by RE companies in fulfilling skills requirements and solutions to be implemented. The survey was conducted from June to September 2016 via email and telephone interviews, from the 23 respondents, eight came from the industry, 10 from the education and training sector, four from governments and one from civil society.

3. Renewable energy education offer

Education data on the IRELP website and databases was analysed for this paper in order to gain an understanding of the current supply of RE training and education worldwide. Data that is referenced in this paper includes records that were published on IRELP as of May 2015. For the purpose of this paper, RE course data provided by IRELP was analysed by technology, region, skill type, language, and course type. While the IRELP course database was updated regularly and was the most comprehensive listing of RE education opportunities to date, the database did not claim to be exhaustive and thus data regarding the geographical and technological spread of RE education included within this paper should be interpreted with a degree of uncertainty.

3.1. Renewable energy education by region

IRELP shows that in total, 40.9% of courses are available in Europe, 33.3% in North America, 12.2% in Asia, and only 6.7% in Latin America, 6.3% in Africa and 3.2% in Oceania. The United States ranks first among countries in terms of the number of courses currently offered, with 662 documented RE courses. The United Kingdom and Germany follow behind with 310 and 186 respectively. India, first developing country, ranks fifth overall, and first within developing countries, with 104 courses currently identified.
3.2. **Renewable energy education by technology**

The most popular category of RE courses is multi-technology, meaning courses that address more than one RE topic. These courses are most often general RE courses, introducing all RE sources and technologies, or provide a focus on two technologies (wind and solar together). Solar energy is the second most popular course focus, with 23.1% of all courses, followed by wind with 8.3%. Geothermal and bioenergy represent 3.8% and 3.4% respectively, hydropower 1.7% and ocean and storage technologies are negligible.

3.3. **Renewable energy education by course type**

Globally, the higher share (32.4%) of RE courses are currently being taught at the master’s level, with short-term professional development training following closely in second (29.1%). Fewer of these courses are offering hands-on training. Only 15.8% being categorized as vocational training and 3.5% as associate level programmes. The remainder are broken down into undergraduate level training and doctorate level education.

3.4. **Discussion on the global offer in renewable energy education**

a) *More acute shortage in developing countries*

From the data it appears that education systems in developing countries, and particularly in Africa, are struggling more than developed countries with adapting to industry needs. The scarcity of RE education and training in developing countries raises concern, particularly when examining data on RE potentials. During the interviews, the most common cited reasons hampering the development of education on renewable in developing countries are: financial constraints, shortage of qualified teachers and trainers and lack of know-how in developing RE curricula.

b) *Mismatch between education offer and industry demand*

The manufacturing, design, development, operation and maintenance of RE projects need specialists with concrete experience in one particular field. There is a low percentage of jobs within the sector that demand a broad overview of the sector. Nevertheless, more than half of the educational offers in renewables have multi-technology curricula. This is clear a mismatch between education offer globally and industry demands.

This finding was confirmed during interviews, however, several experts highlighted that in the near future, with countries advancing with the sustainable energy transition, energy systems will increasingly integrate large shares of decentralised generation and advance sector coupling through electrification of all end-uses. This factor will likely lead to an increased demand for multi-technology professionals over the long-term. This will be particularly true for the building and transport sectors. The very low percentage of education opportunities in hydropower can be explained by the maturity of the technology. Hydropower has been gradually incorporated into existing engineering curricula around the world. While the percentage of the education and training in geothermal energy may appear modest, it is in fact quite high when compared to the total share of geothermal energy in the primary energy globally. The data suggests that the presence of geothermal
education and training is strongly linked to the locations with high resource potential, with the majority of programmes being offered in United States, Iceland, Germany, New Zealand and Japan. There are two notable exceptions to this trend – the lack of education in the Great Rift Valley in Africa and the Andean region in South America. Though the percentage of wind energy education and training is relatively high, the literature review and the interviews conducted suggest that the wind industry is also struggling to communicate with the education system on the skills necessary to further develop the industry. Wind energy companies in Europe are finding it difficult to recruit suitably trained employees and the most frequently cited reason for this constrained supply of labour is the disconnect between skills being taught in educational institutions and those being demanded by the industry, particularly for emerging technologies.

c) Mismatch between the offered educational levels and degrees with the industry demand
The most prevalent skills shortages, particularly in the wind sector, are appearing in construction and installation and in operations and maintenance (EWEA, 2013). These technical roles require practical hands-on training and problem-solving skills. The current focus in RE education globally, however, appears to be on higher education. From the interviews conducted with RE companies, it appears that this trend may be exacerbating the skills gap as employers are struggling more so to find employees with scientific, technology, engineering and mathematics (STEM) skills than they are to fill high-level positions requiring graduate level education. In addition, when recruiting for managerial positions, human resource departments consider experience to be more valuable than a candidates’ academic background. This may suggest that there are currently too many master programmes being offered, and importantly, not enough programmes with an emphasis on hands-on learning.
During the interviews, reasons highlighted for the low levels of vocational training are, the small size of the market and the current structure of the industry. Due to its relatively small size, the sector relies heavily on sub-contracting. These subcontractors do not necessarily have skills specific to the RE sector but are capable of completing, for example, generic electrical work. For the time being, if RE companies are able to outsource these tasks, then they will not have a vested interest in communicating with the education sector and working to build global competencies in these specialized areas. Where specialized technical tasks are required, companies are providing training on the job.

e) The age of online learning
There is strong evidence that students and educators are moving towards the use of online technologies for collaborating, exchange and learning. Of courses documented through IRELP, 12% are taught through online education platforms. This seems to suggest, that while educational institutions may be struggling in some regard to develop face-to-face learning programmes, there has been dramatic growth in the opportunity of online distance learning. Whether or not these online programmes can adequately equip students with the hands-on skills needed for technical trades, however, remains to be seen and is an area in need of greater research.
4. Interest on renewable energy education

4.1. Inquiries through IRELP

The trends on interest on RE education and training were identified by analysing the statistics on the use of IRELP based on Google analytics. The information below includes data on enquiries to IRELP databases from January 2014 to May 2015. Data from the United Arab Emirates has been removed in order to account for over representation resulting from the presence of IRENA in the UAE. By continent, the greatest numbers of users are coming from Asia (41.1%), followed by Europe (28.4%), Africa (14.0%), North America (10.1%), Latin America and the Caribbean and Oceania (4.3%). By country, the highest numbers of users are coming from India (15.6%), followed by the United States (8.6%), Germany (6.7%), Turkey (6.3%), Kenya (4.2%), and the United Kingdom (3.4%). The largest group of users by demographics are 25-34 year olds (33.5%), followed by 18-25 year olds (27.5%), 35-44 year olds (15.5%), 45-54 year olds (5.5%). There were slightly more male users than female, with 54.15% male and 45.85% female.

4.2. Discussion on the interest in renewable energy education

While the 14% of enquiries coming from Africa may look low, taking into consideration the number of RE education and training opportunities currently available in the region and the lower internet access, the level of interest in Africa should be considered high. The very low level of enquiries coming from North America suggests that IRELP was not the gateway to RE education and training in the region. On the other hand, the comparatively very high percentage of inquiries for education and training in German language might show a high level of interest on the further employment opportunities in the sector in Germany.

Regarding demographic patterns, the enquiries by age follow the same pattern as similar sectors of the economy, and the high percentage of enquires from women suggests a higher level of interest from women in RE compared with conventional energy. Companies that were interviewed confirmed that they are witnessing an increased percentage of suitable female candidates in hiring processes. This finding is also supported by a recent study (IRENA, 2017). In addition, human resources experts pointed out that employability of women is higher in the renewables than in the conventional energy sector, because most people find a job thanks to their professional network. Professional networks in conventional energies were established long time ago, they are closed and dominated by men. RE professional networks are being built now, are more open and women in these networks are attracting more women.

5. Conclusions

The foundation of a strong workforce will be pivotal in the global transition from fossil fuels to RE sources. Today there is a critical shortage of skilled personnel to develop, design, finance, build, operate and maintain RE projects. This shortage represents one of the greatest barriers to the wider distribution of RE technologies. There is a need for planning for adequate education and training to satisfy demand for skilled personnel. The current situation is, however, that educational systems are not prepared to provide sufficient and sufficiently skilled workforce as demanded by the
labour market. Currently education and training opportunities in RE technologies are scarce, concentrated in a few industrialised countries with comparatively developed RE sectors. Even in those countries, the demand for skilled personnel remains partly unsatisfied. Existing programmes are not redesigned for the very dynamic RE market. In particular there is a need for more technology specific and hands-on training. In addition to increasing, improving RE education and training, attracting female workers to renewables will facilitate to reduce scarcity of professionals.

Acknowledgements

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References


Malamatenios, C., 2016. Renewable energy sources: Jobs created, skills required (and identified gaps) education and training. Renewable Energy and Environmental Sustainability, Volumen 1, 23.
Experiences from Forty Years of Solar Energy Education

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Abstract
In this paper we aim at upgrading these experiences in curriculum development and about hardware as well as about software in accordance with the development of contemporary knowledge in the field. The scope of the paper includes development of curricula, means for teaching and learning in Science, Technology, Engineering, Art and Mathematics (STEAM). The aim of the study is to create a tentative framework for development of competences for students to be able to meet unknown challenges related to renewable energy during the 21st Century.

Keywords: Solar energy, renewable energy education, science education, curriculum development. North Sun’88, STEAM, sustainability, 21th century competences, OECD.

1. Introduction

Twenty-nine years have passed since the three authors published two papers on experiences from solar energy education (Ott and Broman 1988, Blum et al. 1988). Since then we have for instance started International Association of Solar Energy Education IASEE and the symposium series International Symposium of Renewable Energy Education ISREE (Blum et al. 1993), developed Master programs at University of Oldenburg and Dalarna University (Broman et al. 1998), built science centres with RE exhibits (Kandpal and Broman 2016).

In this paper we aim at upgrading these experiences in curriculum development and about hardware as well as about software in accordance with the development of contemporary knowledge in the field. The scope of the paper includes development of curricula, means for teaching and learning in Science, Technology, Engineering, Art and Mathematics (STEAM).

The aim of the study is to create a tentative framework for development of competences for students to be able to meet unknown challenges related to renewable energy during the 21st Century.

1.2. A proposition for a tentative research question

The rational and framing of this study could, tentatively, be expressed with the challenging question: “Does implementation of renewable energy systems (or education) imply Revolution, Evolution, Enrichment or Provocation of utilization of established and traditional energy sources?”
2. Updating and upgrading of knowledge base in the subject

During the last three months, March, April and May, a focused upgrading of the foundational knowledge base has taken place by participation in appropriate activities:

# 1. Participation in a two day international symposium on the theme: “From Neuroscience to the Classroom.” This symposium was arranged by The Swedish Collegium för Advanced Study (SCAS) in Uppsala on 5-6 April 2017.

# 2. Participation in a two day international symposium on the theme: “Mathematics, language and the developing brain.” This symposium was arranged by AMBLE, Arena for Mind, Brain, Learning and Education, in Göteborg on 9-10 May 2017.

# 3. Participation in a local Workshop, arranged by Neuroforum, Forum for application of neuroscience in schools, in Göteborg in April 19.

# 4. Participation in a conference with operational school leaders in Malmö on 21 March-17.

The theme for this conference was the contemporary problematic school situation in the largest Swedish cities: Stockholm, Göteborg and Malmö. As a preparation for this conference we received a research report in “Future Studies” from Kairos Future about trends in our society.

These studies contributed to widen our perspectives and our theoretical background, in relation to writing this paper for the ISREE conference in Strömstad on 19-21 June 2017.

The two symposia # 1 and # 2 contributed with an updating about our “learning brain” and strengthened our ambition to expose the benefits of adding this aspect of learning to our study about Renewable Energy Education.

The third activity, # 3, the Workshop exposed the need to make a “Quantum leap” from academic lectures to the questions from the participants in order to improve their reception of the presented material.

The forth activity, # 4, stressed the need for a second “Quantum leap”, from talking about problems to actually taking action.

In summary, these inputs could be interpreted as a need, for ISREE, to focus on action in the complex Real World and not just, as we do in established science research, to study a small part of a problem. We have to go beyond this atomistic approach to a holistic approach and then add a timescale in order to establish a systemic approach. This means that we have to study individual learning, social and cultural learning and environmental problems and the possibilities to utilize Renewable Energies, at the same time. All these processes and mechanism interact with each other.

Some books “secondary experiences” gives weight to these arguments:

To these publications, two books by the Nobel Laureate Eric Kandel are appropriate to add. The first book is: “THE AGE OF INSIGHT – The quest to understand the unconscious in Art, Mind and Brain – From Vienna to the present.” 2012, Random House.

It seems that this paper is written in the same spirit that Eric Kandel exposes in these two books: He is searching for insight and a new scientific approach; the old and established roads do not make him satisfied. He wants to go beyond classical ways of explaining phenomena in science.

Let us try to find out where we will land if we study the evolution of Renewable Energy Education in the same spirit! What have we learned during forty years?

3. Theoretical and didactical background

This study is founded on an application of a recent development of the sociocultural theory for learning which was founded by the Russian psychologist Lew Vygotsky (1896 – 1934). By going beyond this theory, the legacy from Vygotsky, we might have reason to study, in a tentative way, a theory named design oriented didactical thinking (Selander, 2017).

From educational neuroscience and neurodidactic we get a lot of useful tools for learning. In the sociocultural theory for learning there are three key concepts: The learning Subject; The surrounding World and the Mediating Artefacts. The Subject is exploring or exploiting the surrounding World with these Mediating Artefacts. These Artefacts may be physical, material tools or non – material tools as for example language, signs or theories.

By utilizing this theoretical approach we get access to a useful toolkit which contains a lot of concepts to be used as tools: Mediation, appropriation, Zone of Proximal Development, enculturation etc. The important fact is that the three key concepts participate in an ongoing cultural and historical developmental process.

The Subject has a biological origin but is born into an ever changing social and cultural context. The physical World is being affected by human actions. The Mediating Artefacts, our tools, are developing rapidly. The physical World has, according to the philosopher Carl Popper, a counterpart in our minds, a mental image of the physical World. In some applications the physical World is substituted by a Virtual Cyberworld.

A seminal citation by Tom Brown (Brown et. al. 2009) is mentioned in (Selander, ibid): Design has the power to enrich our lives by changing our emotions through images, form, texture, color sound and smell. The intrinsically “human – centred” nature of design thinking points to the next step: we can use our empathy and understanding of people to design experiences that create opportunities for active engagement and participation.
The theoretical approach, by Selander, goes beyond, and exceeds the Vygotskian legacy but builds on its social and cultural foundation. The world is regarded from a point of view which takes into account important trends like globalization, digitalization, urbanization, international mass migration and that the world is continually changing. These aspects are not regarded in the symposia mentioned above. These aspects might however become more and more important, especially in the context of Renewable Energy Education, and its connection with Climate Change and Mind Change.

We would however, even, try to go beyond the design inspired theoretical didactical perspective and introduce a neurodidactical, brain based approach in order to deepen the understanding of Renewable Energy Education.

The philosopher Zygmund Baumann characterizes the societal change from the Industrial Modern era as “solid modernity” in contrast to our contemporary post-industrial and postmodern era which he denotes as a liquid modernity (Bauman, Z. 2015). Thus a historically and culturally based approach is introduced.

Our theoretical approach will finally end up in OECD’s model of creation of an Innovative Learning Environment. This model and its applications are described in five publications from OECD Press (See references).

4. Discussion

In our discussion we have to take into account a number of challenges to our contemporary position. These challenges might affect and threaten our personal “comfort zone”. When we respond to these challenges we could instead find it fruitful to introduce the Vygotskian concept Zone of Proximal Development ZPD.

4.1 A Didactical perspective

“The first challenge regards that it is interesting to start with questions about the concept didactic, which includes aspects of teaching as well as of learning. Selander (ibid) point out that the modern design aspect of didactics means to go beyond those classical theories for teaching, some of which build on the transmission paradigm. This implies a challenge of the process when a teachers Pedagogical Content Knowledge, PCK, is thought to be simply transmitted to the student. The student will later at a test try to reproduce this PCK.

The concept design might not only be regarded as associated with for example industrial design which focuses form and function. As a matter of fact, the concept design, has its origin in the unification of form and the creation of meaning. This design oriented didactical perspective, is an evolution of the sociocultural theory for learning. The student is asked to interpret the teachers’ instructions according to her own Mind-set. This means also that the student has to act as an active co - producer of knowledge instead of a passive recipient. This implies also a challenge of the teachers, maybe, slightly more old- fashioned, Worldview.

The important point is that instead of a top – down flow of academically established information we establish a bottom-up counter-flow of demand for meaningful information. This information should be transformed to knowledge by the student – on her own terms.
4.2 A brain based perspective

The second challenge regards that in recent years a new science for education has emerged, educational neuroscience. The American biologist James Zull (Zull, 2011) expresses in the book titled From Brain to Mind a challenge for teachers: Zull proposes that the most important pedagogical challenge in education is to merge results from brain imaging with, for example fMRI, functional Magnetic Resonance Imaging, with the widespread utilization of digital devices for communication for example smartphones, lap-tops and tablets.

From a neuroscientific perspective personal knowledge is regarded as the result of the circulation of small electrical currents in neural networks in a brain. This implies also that new information has to be transformed and integrated with the already situated knowledge. Learning in a neuroscientific perspective has to be “bottom up” on the learners terms.

From neuroscience we learn that our brain has about hundred billion nerve cells, neurons. These are connected by synapses. Our memories are created by changes in these connections. The mantra of neuroscience is “Use it or lose it!” That means that if you do not use your brain, then these couplings will fade. Our brain is thus “plastic” and is affected by the process of learning. The concept life long learning is important to bear in mind.

The neuroscientist Steven Pinker points out that Mind is what Brain does. The neuroscientist Chris Frith has written a book with the title: MAKING UP THE MIND – How the Brain Creates our Mental World.

4.3 A perspective from an innovative learning environment

The third challenge takes its point of departure in OECD’s concept Innovative Learning Environment ILE. This ILE denotes a dynamically changing learning environment which is characterized by seven learning principles, all of which should be fulfilled simultaneously.

These learning principles are:
1. The student should be active and engaged. He is in the center of the learning process.
2. Learning is constructive, social, situated and co-laborative.
3. Learning depends heavily on emotional and motivational factors.
4. The student’s preconceptions and her life experience is a foundation for her learning.
5. The student should always try to exceed her present knowledge and skills.
6. Formative assessment can be regarded as the bridge between teaching and learning.
7. The educational system should strive for “seamless” learning. This means that learning should not only take place as formal education in the school but be supported by informal learning outside the school.

“Could we create an Innovative Learning Environment in Renewable Energy Education?”

This is a challenging question which has resulted in involving utilization of Science Centres, visiting authentic sites and by letting our student actively construct artefacts.

It is also challenging to analyse if renewable energy education might imply:
**Revolution:** We could argue that, for utilization of natural resources for production of energy, a main revolution has occurred. Limited fossil resources could, with the help of modern technology, be substituted by renewable sources in order to create a sustainable society.

From the didactical design perspective we really have to challenge the utilization of fossil fuel. It is better to use renewable energy sources and not to pollute the atmosphere. There is also a challenge created as the development of efficient digital tools makes it possibility to control different processes efficiently.

From the point of view of neuroscience we could find more efficient ways for a student to administer her own learning by *metacognitive means*. This is facilitated if she know a little about the physiological processes in her own brain. For example about how short time and long-time memory systems function. This is a revolutionary aspect useful for learning.

**Evolution:** This aspect is inherent I all scientific achievement. The Noble laureate Richard Feynman has made a citation, which describes science: *Science is not about what we know – science is about what we don’t know.* This implies that in order to do research as a scientist, you are working in a field in constant evolution. We have to take into account evolution of scientific theories which connect theories of learning to social and cultural changes. These didactical methods are possible to be addressed by results from modern neuroscience.

The third challenge is to develop an Innovative learning environment in accordance with OECD’s seven learning principles. We should study case studies based on them and strive to go beyond these principles as OECD proposes in the last book. The seven principles are complemented with three dimensions including networking and leadership. We can regard how renewable energy education is in a continuous development just as culture, society and our Mindsets are.

**Enrichment:** Possibilities for enrichment of traditional education with information about the potential of renewable energies is of course selfevident. Houses can be constructed in other way, solar heating water installations are becoming more and more common. Large and small photo voltaic installations are becoming economically competitive.

**Provocation:** When a new component or new technology is introduced, it will of course be regarded as a provocation by those who have made heavy investments in knowledge and in some technology which is threatened to become obsolete.

### 5. Summary

This study indicates that Renewable Energy Education, to a certain extent, could include aspects of Revolution, Evolution, Enrichment and Provocation of established educational approaches in order to create a sustainable society. This includes different aspects of utilization of fossil energy.

It has however, in this study of renewable energy education, been shown to be valuable to apply a tentative approach to go beyond the established sociocultural theory for learning. It is provocative in itself to apply neurodidactics. It might even be more provocative to introduce a *design oriented neurodidactical approach*. On different levels of application, different educational approaches utilize different insights in science, technology and educational neuroscience.
On a macro level we find it beneficial to regard from a perspective of natural science, light is regarded as a stream of photons giving PV results in photoelectric devices. This technology has been competitive in relation to for example electricity from nuclear plants and hydroelectric plants.

On the meso level, our lifeworld, we have introduces solar heater and different parabolic collectors.

On the micro level we have studied how learning functions in the brain in order to make these processes more efficient.

References


*The ILE Handbook – Preliminary Draft on Internet*. 
A new internal quality management procedure in competence-based higher education –
A pilot study developed with the Postgraduate Programme Renewable Energy

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Abstract
During the last decades, a ‘shift from teaching to learning’ occurred in the European Higher Education Area. Thus, students’ competences are more and more in the limelight. Hence, international researchers, quality assurance agencies and practitioners undertook a joint project in order to develop a new procedure for internal quality management focussing on students’ competences (programme learning outcomes). The procedure consists of three steps: define competences, screen competences and enhance competences. With the aim of validating this new approach, an interdisciplinary team is currently implementing the procedure to the Postgraduate Programme Renewable Energy at Oldenburg University. To conclude, the pilot study encourages discussions of the study programme’s quality and shows the innovative potential of the new procedure for all competence-based programmes.

Key words: renewable energy, internal quality management, competence orientation, competence-based higher education, quality assurance, master’s programme

1. Introduction: shift from teaching to learning

This pilot study aims to evaluate the quality of the Postgraduate Programme Renewable Energy (abbreviation: PPRE). In detail, the interdisciplinary project investigates whether the students of the PPRE programme achieve the pursued competences on the achieved level or if there are gaps between theory and practice.

Among other crucial changes, the so-called ‘shift from teacher to student centred learning’ was a very influential factor for study programmes in the European Higher Education Area within recent decades. In the context of the Bologna Process, many higher education institutions amended their study programmes: they implemented competence-based higher education – their focus moved from input to output, from teacher-centeredness to student-centeredness and from providing instructions to producing learning (cf. IQM-HE 2016, p. 12f.; ESG 2015, p. 6; Barr/Tagg 1995, p.13).

Against this paradigm shift, existing quality assurance measures in higher education are often still concentrating on teachers, their teaching methods and the students’ satisfaction. The typical summative course evaluation can serve as an example for this (cf. Bergsmann et al.
2015, p. 1f.). Still, it is evident that such an elementary development requires new evaluation concepts. For this reason, international researchers, quality assurance agencies, and practitioners developed an innovative procedure focusing on students’ competences: The IQM-Procedure\(^1\). This procedure focusses on the process from defining intended student competences in the beginning to assessing the final perceived competences and drawing measures in the end – “A study programme reaches its goal if the perceived student competences are on the same level as the intended student competences defined in the beginning” (cf. IQM-HE 2016, p. 12). The programme learning outcomes are in the centre of this approach: In contrast to the outcomes on module level, they can be defined as outcomes mediated by the teaching and learning process of a whole study programme (ibid.).

In order to validate the IQM-Procedure, it is currently applied to the Postgraduate Programme Renewable Energy (PPRE) at Oldenburg University.

2. Postgraduate Programme Renewable Energy

Since 1987, the Postgraduate Programme Renewable Energy (PPRE) is offered at the University of Oldenburg (Lower-Saxony, Germany) at the Institute of Physics. Target groups are students with a 6-semester Bachelor’s degree in engineering or science and a professional experience in the field of energy. In the programme, lectures, seminars and laboratory courses are included as well as external practical trainings (internships). In the course of this study programme, students are enabled to foster their skills and develop their competences in renewable energies, so that they can start careers in industries, consultancies, government bodies, NGOs or research institutes after their graduation. For this reason, the curriculum integrates competence-based teaching and assessment methods as labs and outdoor experiments as well as company visits or external trainings in industry or research institutes. Developed from the students’ interests, their laboratory courses and their experience made during their external training, the students are asked to conduct a thesis project in the end of their studies (cf. University of Oldenburg 2017a, University of Oldenburg 2017b).

3. Methodology

In order to evaluate the quality of the competence-based study programme in Renewable Energy, an interdisciplinary team currently applies and implements the newly developed procedure in the PPRE programme. From a methodological point of view, we use a mixed methods approach, which combines quantitative methods for competence screening and qualitative research instruments for discussing the results.

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\(^1\)The procedure is a product of the Erasmus+-Project ‘Internal Quality Management: Evaluating and Improving Competence-Based Higher Education (IQM-HE)’ with the following partners: University of Veterinary Medicine, Vienna, Austria; University of Vienna, Austria; European Association for Quality Assurance in Higher Education (ENQA); University of Economics and Business, Vienna, Austria; Agency for Quality Assurance and Accreditation Austria (AQA); European Association of Establishments for Veterinary Education (EAEVE); Vilnius University, Lithuania; University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, Romania; University of Ljubljana, Slovenia, Carl von Ossietzky University of Oldenburg, Germany. Project website: [https://iqmhe.wordpress.com/](https://iqmhe.wordpress.com/) [29.05.2017]
3.1. Internal Quality Management in Competence-Based Higher Education: the new procedure

The IQM-Procedure evaluates whether students have achieved the competences expressed as programme learning outcomes. The proceeding is conducted in three main steps:

- **Preparation phase** -

1. *Define competences*: elaborate a competence model which fulfils specific quality criteria derived from research
2. *Screen competences*: via questionnaire (from students’ and teachers’ perspective) and/or qualitative interviews
3. *Enhance competences*: initiate concrete measures for quality enhancement

- **Reflection phase** -

*Figure 1* gives an overview about the whole implementation process and its five phases. The detailed steps are explained afterwards.

*Figure 1*: Overview - Implementation of the IQM-Procedure (IQM-HE 2016, p. 50)

**Preparation phase** (February – April 2017):
The general aim of the preparation phase is to inform the decision-makers about the implementation of the IQM-Procedure and to provide an appropriate framework (cf. IQM-HE 2016, 53f.). For this reason, we established an “Internal Quality Management team” (IQM team) with different stakeholder groups (students, teachers, quality managers, administrative staff, alumni, representatives of the labour market). To inform and train all representatives, the quality managers conducted different workshops in which they explained the practical background on the one hand and included practical exercises for application on the other hand. Finally yet importantly, we discussed (personal and time) resources and dedicated some to the project.
**Step 1 – Define Competences (May – July 2017):**

First, the basis of the IQM-Procedure is a list of competence orientated learning outcomes for the study program: the so-called competence model. To elaborate a competence model, the Higher Education Institution has to “define competences students should acquire by [the end of] a specific study programme. These competences can be listed e.g. in the curriculum […]”² (IQM-HE 2016, p.57). Competence research provides five quality criteria (figure 2) for a well-defined competence model³ (ibid.):

| ✓ define competence areas |
| ✓ use a medium degree of abstraction |
| ✓ differentiate two aspects of competence |
| ✓ define competence levels |
| ✓ consider the developmental dimension |

Figure 2: Quality Criteria Competence Model (IQM-HE 2016, p. 58ff.)

As the work on the competence model for PPRE is still in progress, the current status will be constituted in chapter 3.2.

**Step 2 – Screen Competences (August – September 2017):**

The next step will be to conduct a screening in order to check whether the students achieved the intended competence levels or not (cf. IQM-HE 2016, p. 66ff.). For this phase, we will use two online questionnaires for self-evaluation: one questionnaire for students, one questionnaire for teachers. Finally, the screening results have to be analysed to figure out strengths and weaknesses of the programme or curriculum. These steps can be implemented by the person in charge of quality management and with support from the IQM team (representatives of different stakeholder groups: teachers, students, alumni, decision-makers, administrative units, representatives from labour market).

**Step 3 – Enhance Competences:**

Quality management often runs the risk of producing big data sets and detailed reports that are rarely used for quality assurance and quality enhancement. The internal quality management procedure for competence-based teaching expends considerable effort on collecting data and producing a thorough report. However, the internal quality management procedure will also expend considerable effort on using the report (cf. IQM-HE 2016, 73ff.). Therefore, we aim to develop and implement concrete measures to enhance the quality of PPRE. The screening results have to be discussed in the IQM team after the screening is finished. To explore the reasons for detected weaknesses, we will conduct a focus group discussion to discuss developed working theories concerning the following aspects: competences, curriculum, learning strategies, teaching methods, exam formats etc. Thereby, we will discuss possible reasons for gaps between the intended competences and the achieved competences (screening results).

**Reflection phase:**

Part of the IQM-Procedure is a reflection phase, which should complete the whole process. After elaborating a competence model, screening competences and initiating concrete measures based on the results, the aims of the reflection phase are to discuss the success factors of the implementation process and to know how to improve the IQM-Procedure at their higher education institution in the future.

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²Other terms instead of ‘competence’ as objective of a study programme: programme learning outcomes, qualifications or Day 1 skills (cf. IQM-HE 2016, p. 49, 57).
³For a more detailed description of the quality criteria see IQM-HE 2016, p. 57ff.
3.2. Results: competence model PPRE

In the following, we present the current status concerning the competence model for the PPRE programme. The following competences are defined as learning outcomes on programme level, in other terms: What should the students be able to know and perform after graduating?

1. Evaluation of energy resources
2. Explanation of principles of different energy conversion processes
3. Multi-dimensional assessments of renewable energy supply systems and their implementation
4. Socio-economic and ecological evaluation of renewable energy technologies
5. Critical analysis and discussion of the global impact of the energy sector
6. Scientific modelling of renewable energy systems
7. Communication and work in a multicultural and multi-disciplinary team
8. Written and oral communication of natural-science and related topics
9. Application of natural-science related data-acquisition and data-evaluation methods

To explain the competence model in more detail, table 1 demonstrates the structure behind it in an exemplary way, regarding the application of the five quality criteria mentioned before (chapter 3.1, step 1). The competences are grouped in competence areas and formulated on a medium degree of abstraction considering both the cognitive and the practical aspect. Additionally, the competence levels of both aspects are defined.

Table 1: exemplary extract from PPRE competence model

<table>
<thead>
<tr>
<th>Competence Model PPRE</th>
<th>Competence Area</th>
<th>Competence</th>
<th>Aspect</th>
<th>Competence Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) subject related competences</td>
<td>Critical analysis and discussion of the global impact of the energy sector</td>
<td>Cognitive</td>
<td>same level for both</td>
<td></td>
</tr>
<tr>
<td>a) subject related competences</td>
<td>Communication and work in a multicultural and multi-disciplinary team</td>
<td>Cognitive</td>
<td>lower than practical aspect</td>
<td></td>
</tr>
<tr>
<td>a) subject related competences</td>
<td>Written and oral communication of natural-science and related topics</td>
<td>Cognitive</td>
<td>same level for both</td>
<td></td>
</tr>
<tr>
<td>a) subject related competences</td>
<td>Application of natural-science related data-acquisition and data-evaluation methods</td>
<td>Practical</td>
<td>same level for both</td>
<td></td>
</tr>
</tbody>
</table>

Please note that this list is not completed yet, as we are still in the process of reformulating the competences regarding the quality criteria and defining the intended learning outcomes for graduates.
4. Discussion and conclusions

We presented the current results from the pilot project within the PPRE. In summary, our interdisciplinary contribution shows the innovative potential of the IQM-Procedure for all competence-based programmes. We aim to implement the procedure sustainably, so that other study programmes and universities can profit from our experiences.

As stated in the introduction, the implementation of competence-based higher education requires a competence-based evaluation approach. Against this background, the IQM-Procedure has been developed in order to investigate how far students achieved the defined competences on programme level. Even though the actual screening, the enhancing of competences and the reflection phase have not been conducted yet, the experiences we made so far show that the procedure is more than just a simple evaluation instrument. Not only background information about competence-based higher education is given, but also an intensive analysis of the study programme’s competences takes places: Are our competences formulated according to the quality criteria? Is the list of our competences complete? What do relevant stakeholder groups consider? What are the real learning goals of our study programme?

Already at the current stage, the IQM-Procedure offered extensive ‘food for thought’ for all persons involved – it is likely that the upcoming steps will also offer valuable impulses on different levels.

References


Sustainable development, CO2 emission and alternative of energy In Middle East Countries and Iran.

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Abstract:
Although the electricity generation over the world is categorized by fuel types of coal, natural gas, hydro, nuclear and oil by means of 41.5%, 21.9%, 15.8%, 11.7% and 4.8% respectively in 2011. The electricity generation via natural gas over the world has been considered for U.S.A, Russia, Japan and Iran respectively. Therefore Iran is considered as the most natural gas consumer for electricity generation in the region by means of the forth. Other consideration was made for the most CO2 missioner in the region, which is classified for Iraq, Kuwait, Saudi Arabia and Lebanon by means of gr/kwh %respectively. Where CO2 emission over the world seems higher by means of MT% and in the order of OECD 39.4%, China 25.5% and Asia 11.1% respectively. So the least rate of CO2 emission belongs to Middle East countries by means of 5.1% over the world. Sustainable Development has been considered by means of less CO2 emission over the world till 2035 which could be regarded as OECD 27.6%, China 22.4%, Asia 19.6%, but Middle East 7.7% by means of renewable energy substitution over the world. The renewable energy substitution in The Gulf state is made as Saudi Arabia 50% by 2020, by means of PV and wind electricity generation as the first, Oman as the second by means of 10% by 2016, Bahrain 5% by 2020, Quatar 2% by 2020 and Iran n/a through Middle East countries.

Key Words: Electricity generation, CO2 Emission, Oil and Gas consumption, Sustainable Development and Renewable Energy.

1. Introduction:
Our economies especially those of industrial countries are completely dependent on fossil fuels of Coal, Oil and N.G. These are non renewable that we shall exhaust one day. Indeed Each stage in the exploration, extraction, processing and transportation. At the time of oil crises renewable were seen as the long term solution to finite fossil fuel reserves. Fossil fuels provide energy via combustion and in the process release emissions that are toxic to flora and faun. Some of these emissions may be changing the earth’s climate. By means of impacts and is suspected risks for humans and ecosystems. In the years there after renewable were further supported based on variety of agreements ranging from its contribution to securing energy supply to strength the competitiveness of the electricity supply and providing the first real market opportunity to develop band products. The most prominent agreement nowadays is the contribution of renewable and other alternatives to compensate the climate change. In this study
natural gas consumption for electricity generation has been considered over the world and in Middle East countries as an alternative of energy. Considerations were made for CO2 emission due to electricity generation and fuel consumption in OECD, China and Asia respectively. Sustainable development was regarded to be considered by CO2 reduction and renewable energy development in Middle East countries especially China.

2. Material & Methods:

Effort has been made for data processing of IEA 2013 web site and with the use of the annual reports of Energy Balance of Iran for the period of this study. Besides, other surveys. Which has been made through periodical Journals. To achieve CO2 emission and power plants characteristics of Iran dealing with the environmental aspects as an overview of this study.

3. Conclusion and results:

Conclusion were made for electricity generation from natural Gas distribution over the world considered for U.S.A, Russia, Japan and Iran by means of first, second, third and the fourth position respectively. Fig.1. Where the electricity generation by Middle East has been considered as 3.6% whole. Therefore the growth of CO2 emission has been considered relatively to OECD, China and Asia in terms of MT% and in the order of 39.4%, 25.5% and 11.1% respectively. Fig.2.

Other consideration were made for CO2 emission in region by means of Iraq, Kuwait and Saudi Arabia due to N.G. consumption and by means of 903.3gr/kwh, 787gr/kwh and 754.4 gr/kwh respectively. Fig.3. GHG emission has been considered Via power plants in Iran. Which is of great interest by means of Diesel P.P. Steam P.P. Gas P.P and Conventional P.P. respectively, Fig.4. Therefore the air pollutants consideration due to the high N.G. consumption in Iran has been considered for CO, Ch4, NO2, NOX, and SO2 and CO2 respectively?

Sustainable development will be achieved by Co2 emission reduction predicted for 2035. Which is in terms of 27.6% for OECD, 25.5% for China, 3.40% for Asia. Besides the rate of 9.1% for Non OECD and 7.7% for Middle East countries to achieve till 2035, Fig.5.

4. Discussion:

Fossil fuel consumption and CO2 emission has been considered over the world, especially in Middle East countries. Conclusions were made for electricity generation due to oil and natural gas consumption and CO2 emissions. Although the electricity generation by fuel type over the world has been classified by Coal, Natural Gas, Hydro, Nuclear, Oil and others respectively. Electrici 
generation from oil has been considered in terms of TWh has been categorized for Japan 153, Saudi Arabia 142, and Islamic Republic of Iran 67(TWh) respectively. Where electricity generation by natural gas in terms of TWh over the world has been considered for U.S.A as the first, Russia Federal as the second, Japan as the third and Islamic republic of Iran as the Fourth, Fig.1. The fuel consumption by region over the world has pointed out for OECD (41%), China (18.4%), and Asia (12.5%) in terms of TWh. Fig.2. Besides the CO2 emission by regions in 2011 has been considered for OECD, China and Asia by means of 35%, 25% and 8% respectively. But the CO2 emission in Middle East Countries is contributed as 5. %. Fig.3

Considerations were made for CO2 emission by Natural Gas for electricity generations in the region as Iraq, Kuwait, and Oman by means of 903, 787.2and 754.4 (gr/kwh) respectively. Iran has been considered for its power plants in the order of Diesel, P.p.962.9, Steam, p.862.2, Gas p.p.849.8, and conventional p. p 483.1 (gr/kwh) respectively, Fig.4. Other important air pollutants by power plants in Iran are in the order
of CO2 (30.2%, NOX (39.4%) and SO2 (38.2%) in terms of gr/kwh. Other air pollutants due to N.G. consumption in Iran has been considered through transportation rather than power plants. Which is in the order of CO(91.7%), CH4(79.7%) and NO2(50%). Therefore the CO2 emission in Iran is negligible out of 5% in Middle East countries as a whole. Sustainable development by means of CO2 reduction prediction by IEA has been regarded as the result of this study by means of OECD 27.6%, China 22.4%, Asia 19.6%, and Middle East 7.7% (MT%) till 2035, Fig.5.

Fig.1. Electricity generation via N.G over the world, 2011... Fig.2. Eng. Consumption over the world by region, 2011
Fig. 3. Co2 emission over the world by Region

Fig. 4. CO2 via P.P in Iran

Fig. 5. GHG in Iran 2011
5. References:

3- The People Republic of China, Initial National Communication on Climate Change (IEA.2000)
Quality Renewable Energy Training Programs for Technicians

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Abstract
This paper summarises a Guideline for Introducing Quality Renewable Energy Training Programs that will be jointly published in 2017 by the IEA-PVPS and ISES. The Guideline has been developed by GSES to help relevant stakeholders understand what a Quality Training Framework comprises and how quality renewable energy training courses should be developed. The paper includes examples of where quality renewable energy training programs have been introduced. This paper and the Guideline focus on Technician training, however the same principles apply to all facets of the renewable energy industry.

Key words: technician training, frameworks, quality training, certification, accreditation

1. Introduction

In mature industries companies are able to employ technicians who have obtained their skills training from accredited and approved training centres\(^1\). These training centres are offering courses that meet the needs of the relevant industry. Such a training framework is achieved through established committees comprising relevant stakeholders from industry, training institutes and at times government, who identify and document the knowledge and skills required to perform a certain task, for example the installation of grid tied PV systems. The development of documents which set the required standards follows similar procedures around the world, however they often have different names such as: Competency Standards, Units of Competence or Job Task Analysis. Within the Guideline Unit of Competence is utilised as the generic term for the variety of names.

Training institutes become accredited and/or approved to conduct these courses via an auditing process undertaken by a recognised body, often a government or semi-government entity. In addition to the approval to conduct specific training courses, the training centres are audited and approved against a set of quality management/organisational standards with the objective that the training centres are providing quality service.

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\(^1\) This document uses the term training centres for describing an entity that provides technical training for technicians. In some countries these could be called training institutes, technical colleges, polytechnics etc.
In many countries the process is part of a *National Qualifications Framework* or *National Quality Training Framework*. Sometimes they can be regional and not national. These frameworks document the various qualifications that could be available through training centres (including Universities, technical colleges and similar), ranging from certificate level courses through to postgraduate degrees.

Though the renewable energy industry has increased dramatically worldwide over the last 10-15 years, the training of the required technicians within approved and accredited training centres has not kept pace with the industry’s requirements. There are only a small number of countries where specific renewable energy training is already within the country's training framework.

### 2. Components of a Quality Training Framework

Most people do not necessarily understand quality training frameworks, they just accept them if they have already been implemented within their industry. However, since there is a great need for quality renewable energy training at the technician level globally, many of the stakeholders need to understand what a training framework is. If not, stakeholders will talk about the need for quality training without it actually being successfully introduced in their country or region. For this reason, the Guideline provides an overview of what is a quality training framework and how it operates. It states that successfully introducing renewable energy training within an existing national or regional framework will require close liaison between the renewable energy industry stakeholders and the existing education stakeholders.

The overview of quality training frameworks in the Guideline provides examples of the key elements that are included in the quality management standard which an approved training centre should be audited against. The quality management requirements are common for all training centres, independent of what industries the training centre is offering courses in. As an example, a quality management standard will include areas such as:

- Procedures relating to processing student applications.
- Minimum qualification requirements for teaching staff and their continuing professional development.
- Policies related to health and safety.
- Policies related to conducting assessments.
- Policies and procedures related to complaints.

The overview section of the Guideline provides an explanation about curriculums and Units of Competence. It refers to existing documents showing the different formats on how these can be presented. Though some Units of Competence might be common across industries, there will always be specific Units of Competence unique to a particular industry.

### 3. Technician certification/accreditation schemes

To raise the professionalism and sometimes credibility of an industry some industries have industry based certification or accreditation programs where trained individuals
participate through undertaking ongoing (continuing) professional development activities to distinguish themselves from other people in their industry. The Guideline summarises some of the schemes introduced for the solar industry.

4. **Introduction of quality renewable energy training in a country or region**

After providing an overview of quality training frameworks the Guideline describes what should be undertaken to introduce quality renewable energy technician training into a country or region. The first step should be undertaking a needs and gap analysis which should identify information such as:

- The current and future market prospects for the various technologies and their applications.
- How many trained people per year are required for each technology application?
- Any training programs that are currently available and what training has been conducted in recent years.
- Whether the country or region has an existing quality training framework.

Based on the results of the needs and gaps analysis, training courses should be introduced for the technology applications identified, however the Guideline describes all things to be considered, not just the development of the Units of Competence. These include:

- Identifying where training should be conducted.
- Not flooding the market with too many training centres and too many trained technicians.
- The format of the training.
- The material that training centres will require.
- Training of the trainers.

If a framework already exists for a country or region then there will already be training centres that meet the quality management requirements. In introducing renewable energy training courses within that country or region, then the industry stakeholders should be able to work with these existing, approved training centres. Industry stakeholders will have to lead the development of the Units of Competence required for their industry.

The procedures for the development of Units of Competence are common and independent of the industry. Though the existing training centres would have experience in the development of Units of Competence the Guideline does have a section dedicated to their development and in particular: how committees are formed; how they operate; how the Units of Competence are developed and approved. The reason is, if the renewable energy industry does want quality Units of Competence relevant to their industry needs they need to take control of the process and have a very good understanding of the process.
5. What if there is no country Quality Training Framework for the Vocational Training sector?

Though quality training frameworks do exist in a number of countries there are a number of countries where they do not. This raises the question on whether there is a need for an international body that could accredit and approve renewable energy training centres? A section summarises work undertaken previously by a body established in 1996, the Institute for Sustainable Power, to provide this service and explains why at the time it was unsuccessful, namely because of the small size of the industry. The Guideline suggests activities to identify whether such an organisation would still be useful.

6. Examples of existing Quality training and technician’s certification/accreditation schemes

The Guideline provides examples of the introduction of a number of quality renewable energy training programs internationally including West Africa (ECREEE), France, India, Kenya, Malaysia, the Pacific region, South Africa, Singapore, and the United Kingdom. However, when providing examples of frameworks and Units of Competence (Job Task Analysis) it focuses on Australia and the USA. These have not been included to imply that they are better than any other countries’ programs, they have been selected because:

1. though they are different in one being compulsory (Australia) and the other being voluntary (USA), they are similar in operation and do show how most frameworks around the world are basically similar with only small differences; and
2. they are examples of some of the longest operating quality training programs being applied to the renewable energy industry and hence are quite mature.

Australia introduced a solar technician accreditation program in 1993 (now compulsory to work in specific sectors of the industry) and introduced renewable energy technician training into their technical colleges as early as 1989. From the late 1990’s these programs were included in the national training framework and were compulsory for all renewable energy training courses offered in Australia to be endorsed within the relevant national training package and provided by registered training organisations.

7. Framework examples

The Australian Quality Training Framework (AQTF) governs how all education and training is conducted within Australia. It is the national set of standards to assure nationally consistent, high-quality training and assessment services for the clients of Australia’s vocational education and training system. Figure 1 provides a flowchart on how the Australian Quality Framework interacts with all the stakeholders.
Irrespective of whether a scheme is compulsory or voluntary, which applies across all industries, not just renewable energy, there are essential components common to each for the training and certification of participants, which are shown in Figure 2.
Figure 2: Important components of a Quality Training Framework
Abstract

In this research paper, an attempt has been made to explore the knowledge and skill set requirements of solar power industry and the role of University of Petroleum and Energy Studies in capacity building for solar power industry in India.

Keywords: Capacity building; solar jobs; knowledge and skills

1. Introduction

At Paris Climate Summit in 2015, India committed to reduce its emissions by 33-35% of 2005 emissions level with 40% of its installed capacity from non-fossil fuels. To achieve the same, the target of National Solar Mission of India has been revised from 20,000 MW to 1,00,000 MW installed capacity of solar grid power by the year 2022 (PIB, 2015). Considering the current installed capacity of 9,013 MW solar power (CEA, 2017), India is at a nascent stage in solar power development and achieving the goal of National Solar Mission is going to be challenging. Adequately trained manpower is crucial to the development of solar power industry in any country (Garg and Kandpal, 1996; Kandpal and Broman, 2014). There are several academic institutions in India providing education and training in the field of solar energy (Table 1). It is evident from the table that University of Petroleum and Energy Studies (UPES) offers more versatile programmes that develop skilled manpower for almost all job profiles in engineering, management and law disciplines of solar power industry. The university also strives to maintain strong symbiotic relationship with solar power industry by inviting industry professionals for regular talks and lectures (UPES, 2017). Consequently, almost all top-notch solar companies in India like Adani Solar, Acme Solar, Azure Power and ReNew Power regularly recruit students from UPES (Placement Officer of UPES, Personal Communication, May 11, 2017).

In this research paper, an attempt is made to explore the knowledge and skill sets required in solar power industry and the linkage between the human resource requirements of the industry and the courses offered by UPES. Additionally, the paper compares solar energy related curriculum of UPES with the relevant curriculum of some prestigious international universities to seek opportunities for curriculum enrichment through academic collaboration.
Table 1: Solar energy related programmes offered by premier energy focused institutions in India (IIT Delhi, 2017; IIT Bombay, 2017; NPTI, 2017; TERI University, 2017; PDPU, 2017; UPES, 2017a)

<table>
<thead>
<tr>
<th>Academic Institution</th>
<th>Solar Energy Related Programmes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre for Energy Studies, Indian Institute of Technology Delhi</td>
<td>Master of Technology (Energy Studies); Master of Technology (Energy and Environment Management)</td>
</tr>
<tr>
<td>Department of Energy Science and Engineering, Indian Institute of Technology Bombay</td>
<td>Master of Technology (Energy Systems Engineering)</td>
</tr>
<tr>
<td>National Power Training Institute</td>
<td>Master of Business Administration (Power Management)</td>
</tr>
<tr>
<td>TERI University</td>
<td>Master of Science (Environmental Studies and Resource Management); Master of Technology (Renewable Energy Engineering and Management)</td>
</tr>
<tr>
<td>Pandit Deendayal Petroleum University</td>
<td>Master of Technology (Energy Systems focused on Solar Energy)</td>
</tr>
<tr>
<td>University of Petroleum and Energy Studies</td>
<td>Master of Business Administration (Power Management); Master of Technology (Energy Systems); Master of Technology (Renewable Energy); Bachelor of Laws (Specialization in Energy Laws)</td>
</tr>
</tbody>
</table>

2. Knowledge and Skill Sets Requirement of Solar Power Industry

Achieving 1,00,000 MW grid-connected solar power by 2022 would require adequate number of competent and well trained professionals for resource assessment, technology development, system design, installation, operation, maintenance, performance monitoring, information processing, planning, etc. (Kandpal and Broman, 2014). For sustained growth in solar power, it is imperative for a country to have a conducive policy and regulatory framework for all stakeholders of the industry complemented by appropriate research and development initiatives (Painuly, 2001; Yaqoot et al., 2016). Once appropriate policy and regulatory framework creates a fair market for solar power stakeholders with adequate incentives to sustainable energy and internalization of externalities, project developers may get interested in solar power projects (Painuly, 2001). Development of solar power projects involve business development initiatives followed by project management activities namely project planning, project financing, engineering (design), procurement, logistics, construction, commissioning and project control. Material demand of solar project developers is generally fulfilled by indigenous manufacturing or imports from countries such as China and USA. Once solar power project is constructed and commissioned, operation and maintenance activities keep the solar power plant running. Thus, solar power development creates job opportunities in research and development, regulatory, business development, project planning, project financing, engineering (design), procurement, logistics, construction, commissioning, project control, manufacturing, import, operation and maintenance profiles. A study on potential of job creation by solar power projects in India had earlier estimated that during 2011-2014, about 23,884 jobs were created in broad profiles namely business development, design and pre-construction, construction and commissioning, and operations and maintenance (CEEW and NRDC, 2014). Table 2 presents a snapshot of knowledge and skill sets required for job profiles associated with solar power industry. It is worth highlighting that all solar job profiles demand good understanding about working principle
of solar power project components and the prerequisite knowledge and skills presented in Table 2 are additional requirements. List of prerequisite knowledge and skills indicate that academic institutions can play a crucial role in capacity development for solar power sector by imparting appropriate knowledge and skills to the students.

Table 2: Prerequisite knowledge and skills for various job profiles of solar power industry

<table>
<thead>
<tr>
<th>Solar Job Profile(s)</th>
<th>Nature of Job Profile</th>
<th>Prerequisite Knowledge and Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research and development</td>
<td>Technical</td>
<td>Material science, resource assessment, applied engineering</td>
</tr>
<tr>
<td>Regulatory</td>
<td>Legal</td>
<td>Regulatory framework of power sector</td>
</tr>
<tr>
<td>Business development</td>
<td>Managerial</td>
<td>Marketing and sales</td>
</tr>
<tr>
<td>Project planning, Project control</td>
<td>Managerial</td>
<td>Project management</td>
</tr>
<tr>
<td>Project financing</td>
<td>Managerial</td>
<td>Financial management</td>
</tr>
<tr>
<td>Engineering (Design)</td>
<td>Technical</td>
<td>Design</td>
</tr>
<tr>
<td>Procurement and Logistics</td>
<td>Managerial</td>
<td>Project management</td>
</tr>
<tr>
<td>Construction</td>
<td>Technical</td>
<td>Project construction</td>
</tr>
<tr>
<td>Commissioning</td>
<td>Technical</td>
<td>Control systems</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Technical</td>
<td>Production engineering</td>
</tr>
<tr>
<td>Import</td>
<td>Managerial</td>
<td>Export-Import procedures</td>
</tr>
<tr>
<td>Operation, Maintenance</td>
<td>Technical</td>
<td>Functioning of equipment and control system</td>
</tr>
</tbody>
</table>

3. Contribution of UPES to National Solar Mission

As presented in Table 2, depending on the nature of job profile, employment opportunities in solar power may require varied combination of knowledge and skills. A pioneer in energy education in India, UPES has been offering courses addressing various capacity building issues of solar power industry since 2003 (UPES, 2017). A snapshot of UPES’s solar energy related academic programmes, courses and targeted solar job profile is presented in Table 3.

In addition to offering solar energy related courses targeted at various job profiles, it is necessary for an education institution to periodically seek inputs from the industry professionals about any gap(s) between existing and desired levels of education and training (Kandpal and Broman, 2014). Through its annual course curriculum review meetings, UPES has a formalized process where academic departments interact with industry professionals to seek inputs on curriculum to keep it relevant to the industry (UPES, 2017). This allows the departments to foresee industry trend and adopt accordingly to ensure employability of graduating students.

4. Curriculum Enrichment Opportunities for UPES

Several prestigious international universities are offering solar energy related academic courses (Table 4). In comparison to the courses offered by UPES, the courses offered by the international institutions have seemingly higher degree of fundamental research component in terms of: a) material science research for cost reduction of solar PV panels; b) energy, environment and
sustainability relationship: c) creation of a fair energy market for clean technologies such as solar PV. This indicates ample scope for collaborative work between UPES and the international institutions where UPES can collaborate with them to engage in cutting-edge fundamental research. Simultaneously, the international institutions can work with UPES to appreciate capacity building issues with large scale (1,00,000 MW) integration of solar power to the national grid of a country as socio-economically and geographically diverse as India. In addition, through faculty and student exchange programmes between UPES and international institutions, experiences can be shared to enrich the solar energy related curriculum.

Table 3: UPES’s solar energy related academic programmes, courses and targeted solar job profile

<table>
<thead>
<tr>
<th>Academic Programme</th>
<th>Solar Energy Related Courses</th>
<th>Targeted Solar Job Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master of Business Administration (Power Management)</td>
<td>Power generation and power station management</td>
<td>Operation, Maintenance</td>
</tr>
<tr>
<td></td>
<td>Solar power development and management</td>
<td>Construction, Commissioning, Maintenance, Project financing, Regulatory</td>
</tr>
<tr>
<td></td>
<td>Project management and contract administration</td>
<td>Project planning, Project financing, Construction, Commissioning, Project control</td>
</tr>
<tr>
<td></td>
<td>Marketing management</td>
<td>Business development</td>
</tr>
<tr>
<td></td>
<td>Regulatory framework in power sector</td>
<td>Regulatory</td>
</tr>
<tr>
<td></td>
<td>Supply chain and logistics for power industry</td>
<td>Procurement, Logistics, Import</td>
</tr>
<tr>
<td></td>
<td>Power sector planning and integrated power resources management</td>
<td>Project planning</td>
</tr>
<tr>
<td>Master of Technology (Energy Systems)</td>
<td>Project &amp; financial management in energy sector</td>
<td>Project planning, Project financing, Construction, Commissioning, Project control</td>
</tr>
<tr>
<td></td>
<td>Renewable energy technologies - I</td>
<td>Research and development, Engineering (Design), Operation, Maintenance</td>
</tr>
<tr>
<td>Master of Technology (Renewable Energy)</td>
<td>Project &amp; financial management in energy sector</td>
<td>Project planning, Project financing, Construction, Commissioning, Project control</td>
</tr>
<tr>
<td></td>
<td>Solar power generation through PV route, Solar thermal technologies</td>
<td>Research and development, Engineering (Design), Manufacturing, Operation, Maintenance</td>
</tr>
<tr>
<td></td>
<td>Renewable energy policies</td>
<td>Regulatory</td>
</tr>
<tr>
<td>Bachelor of Laws (Specialization in Energy Laws)</td>
<td>Law relating to new and renewable energy</td>
<td>Regulatory</td>
</tr>
<tr>
<td>Academic Institution</td>
<td>Solar Energy Related Programme(s)</td>
<td>Solar Energy Related Course(s)</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>----------------------------------------------------------------</td>
<td>-------------------------------------------------------------------</td>
</tr>
<tr>
<td>Oregon Institute of Technology</td>
<td>Bachelor of Science (Renewable Energy Engineering)</td>
<td>Solar photovoltaics, Solar thermal energy</td>
</tr>
<tr>
<td>University of California Berkeley</td>
<td>Master of Business Administration (Energy and Clean Technology)</td>
<td>Energy and environment markets, Cleantech to market, Energy and infrastructure project finance, Renewable energy speaker series</td>
</tr>
<tr>
<td>University of Texas Austin</td>
<td>Bachelor of Engineering (Energy Systems and Renewable Energy)</td>
<td>Renewable energy and power systems, Development of a solar powered vehicle, Solar conversion devices</td>
</tr>
<tr>
<td>University of Michigan</td>
<td>Master of Engineering (Energy Systems)</td>
<td>Sustainable energy systems</td>
</tr>
<tr>
<td></td>
<td>Master of Engineering (Sustainable Systems)</td>
<td>Renewable electricity and the grid, Green development, Strategies for sustainable development, Energy markets and energy politics, Cleantech entrepreneurship, Energy project finance</td>
</tr>
<tr>
<td>European Solar Engineering School, Dalarna University</td>
<td>Master of Science (Solar Energy Engineering)</td>
<td>Solar radiation and solar geometry, Solar thermal, Economics of solar energy, Photovoltaics, Applied solar engineering, Solar thermal design, PV and hybrid systems design, The social context of energy systems, Scientific communication and information management, Energy storage, Sustainable energy systems, Solar building design, Project course in solar energy systems or energy efficient buildings, Dynamic simulation of energy systems, Solar thermal power, Global perspectives in solar energy</td>
</tr>
</tbody>
</table>
5. Conclusion(s)

Solar power industry creates job opportunities in research and development, regulatory, business development, project planning, project financing, engineering (designing), procurement, logistics, construction, commissioning, project control, manufacturing, import, operation and maintenance profiles. UPES has played a significant role in capacity building for National Solar Mission by imparting suitable technical, managerial and legal education and training required by various solar job profiles. UPES can further enrich its curriculum through collaborations with prestigious international academic institutions.

References


PIB, 2015. Revision of cumulative targets under National Solar Mission from 20,000 MW by 2021-22 to 1,00,000 MW. Press Information Bureau (PIB), Government of India. New Delhi.
