3.1 The role of resource efficiency in engineering education

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Abstract

The purpose of this paper is to address various issues of resource efficiency in the perspective of engineering education in the Middle East and North Africa (MENA) region, with particular focus on Occupied Palestinian Territory (Palestine). First, the paper reviews the concept of resource efficiency from several perspectives including energy, electricity and water related challenges, material management and solid waste management. Then the current state of the education and training is discussed along with some details regarding the developed resource accounting perspective for engineering education. Open knowledge platform is foreseen to aid the transition from problem to solution, bringing engineering education up front to tackle the resource efficiency challenges in the MENA region. Finally, capacity building through university graduates is considered as an important mechanism for raising awareness in resource efficiency.

Keywords:
Resource efficiency, renewable energy, water treatment, waste treatment, engineering education.

1 INTRODUCTION

Some countries in the Middle East and North Africa (MENA) suffer from limited natural resources especially water, materials and energy. Water shortage is considered as one of the main problems in the MENA hence measures and policies to use it efficiently are urgent in this region. Shortage in conventional resources of energy is another major problem for some countries like Jordan and Palestine; this could be partially solved using sustainable and renewable energy resources. On the other hand municipal solid waste as well as material wastage in the industries is a major challenge for resource efficiency and competitiveness.

Resource is an economic or productive factor required to accomplish an activity, or as means to undertake an enterprise and achieve desired outcome. Resource efficiency needs a consistent definition, between nations, disciplines and business sectors. According to the European Commission, resource efficiency allows the economy to create more with less, delivering greater value with less input, using resources in a sustainable way and minimizing their impacts on the environment. Similarly, the United Nations Environment Program (UNEP), defines resource efficiency as to ensure that natural resources are produced, processed, and consumed in a more sustainable way, reducing the environmental impact from the consumption and production of products over their full life cycles. Although there are many definitions of resource efficiency, almost all agree that the three most basic resources are land, labor, and capital; other resources include energy, entrepreneurship, information, expertise, management, and time. Resources considered in this paper include: water, material and energy. Resource efficiency can be improved through optimization of productive use of resources at all stages of the production/consumption cycle. Inadequate use of resources creates waste. Resource efficiency hence aims to maximize the useful usage of resources and minimize waste. This goal can be achieved by controlling the efficiency in stages of: design, production and consumption.

Designing a product that saves the resource consumption is one approach for resource efficiency. Producing the product using efficient processes is the second approach. Efficient use of the product produced is the third approach. A three-step approach for analyzing the potential for resource efficiency improvement are [1]:

- The first step involves the analysis of the current consumption of materials, and the presentation of a breakdown of the consumption.
- In the next step efficiency improvement measures are identified and their effects on material and energy consumption are calculated.
- In the last step the measures are evaluated and the total results are calculated.

Reducing requirements for production of new (virgin) material would lead to reduced rates of extraction of natural resources, reduced energy and water demand, reductions in emissions and other environmental harms, and potentially has national political advantages through offering a reduced dependence on imports and increased self-reliance. Options

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to reduce emissions, while meeting market demand for materials, through energy and process efficiency. This ambition has already driven strong interest in the pursuit of [2]: increased recycling; material substitution; powering industry with low-carbon electricity; carbon capture and storage. Additional material efficiency strategies, that might provide a significant reduction in the total environmental impact of the global economy include [3], [4]: component re-use; longer life; more intense use, repair and re-sale; product upgrades, modularity and remanufacturing; options for change that will use less materials to provide more services [5], [6].

Engineering education is one of the major drivers behind resource efficiency. Building required skills, human capital as well as offering the technical/technological innovation to improve sustainability. The paper outlines Open Knowledge Platform for Resource Efficiency (OKPRE), being proposed to aid educational efforts, creating and sharing knowledge and raising awareness to achieve changes in societal behavior, production and consumption patterns, and to set up for more inclusive participation with regard to resource efficiency. In this respect the OKPRE is intended to aid education and raise awareness by enabling a multi-stakeholder participation, dialogue, exchange of best practices and partnership for resource efficiency.

2 PROBLEMS IN RESOURCE EFFICIENCY

2.1 Energy challenges in MENA region

Energy acts as a main indicator of industrial activity and improved standard of living. GDP is correlated easily with energy per capita consumption or domestic material consumption influencing resource productivity. For non-fossil fuel producing countries in the MENA region such as Palestine energy supply can be a limiting factor of growth and prosperity. Maximizing the use of the available energy resources on one hand and utilizing renewable energy resources on the other hand will be the wise option for such countries. This issue becomes extremely important in view of 70% increase in demand for primary energy over the next 20 years.

2.2 Electricity and water in MENA region

In Palestine, the electricity grid reaches 99% of population unlike other countries in the region. Even in the oil rich countries the electricity grid and supply is not 100%. Palestinians in the West Bank do not generate their electrical power. The total power purchased is around 98%, the bulk is supplied by Israel, and Jordan provides around 6%. In Gaza Strip, Israel supply 50% and Egypt supply 7%. The rest is supposed to be generated by the Gaza 140-MW Power Station (GPS). Main problem in Palestine is the equality of electricity and it duration. Interruptions and break downs are very frequent in winter time. In Gaza Strip situation is much worse due to the unavailability of fuel for the GPS, such that it operates only a few hours a day. People depend for most of the time on diesel generators generating electricity at a high price and polluting the environment. Other constrains when it comes to energy is the price and the cost. Electricity prices in Palestine are very high because almost all energy is imported from Israel at a relatively high cost and then taxed by the Palestinian Authority. The average selling price of electricity is 0.115 €/kWh. There are no subsidies; energy therefore takes a large part of the household income of Palestinians. The average annual income per capita in Palestine is 1,030 €; the electricity bill amounts to about 10% of the family income [7].

In general the MENA region suffers from shortage of water. Countries like Jordan and Palestine in particular suffer from continuous increase of the water scarcity. Climate changes and environment issues are adding to already present political concerns over the water problem [9]. Palestinian water abstractions have declined over the last ten years, as the result of the combined effect of dropping water tables, Israeli restricted drilling, deepening and rehabilitation of wells. Water withdrawals per capita for Palestinians in the West Bank are about one quarter of those of the Israelis, and are continously declining over the last decade. By regional standards, Palestinians have the lowest access to fresh water resources as shown in the table 1 below [10].

Table 2: Per capita availability of renewable water resources in Jordan basin (Sources: World Bank, 2007, PWA, [11]).

Country	m^3 per capita per annum
West Bank	75
Gaza	125
Jordan	200
Israel	240
Lebanon	1200
Syria	1500

2.3 Material management

Material management is an engineering technique concerned with planning, organizing and control of flow of materials from their initial purchase to destination [12]. Material management aims at getting the right quality and quantity of supplies in the right time and place at the right cost. The objectives of material management refer to material planning, purchasing, procuring, storing and inventory control. On the other hand, material management helps in organizing supplies, distribution and quality assurance of materials. In general, the best procedure for material management flow is outlined in Figure 1 that represents a material management cycle [12].

(MENA) region suffers from shortage in different types of materials that are considered vital for development of this region. Therefore, it is even more important to use adequate management techniques to manage the most important material resources like petroleum and construction materials to sustain the resources for a longer period. Stone, marble and aggregate make up to 50% of materials used in construction. Managing the life cycle of this material will improve the efficiency of this resource and the regional economy as well [13]. The rest of materials used in construction are divided into metals and non-metals. The most widely used metal is steel followed by aluminium while the non-metals relate to rubber, plastic, and wood. Petroleum producing countries in MENA depend on oil and gas, responsible for 90% of their GDP [14].

Figure 1: Material management flow diagram

2.4 Solid waste management

Waste increases with the increase in population and development. To minimize the adverse impacts of waste on environment and humans, it is necessary to manage and prevent waste. Management process is handled by planning and implementing a complete programme for waste collection, transport, disposal and recycle/reuse. Waste prevention is better than waste management. Waste prevention can be done by designing longer life products, reducing packaging and reusing materials and products. The second process is recycling and composting. Recycling can be done by recollecting used materials such as paper, plastic, glass and metals and reuse or remanufacture them. Some organic wastes are rich in nutrients and can be used to improve soils in composting process. Recycling process reduces solid waste quantities and on the other hand, it creates job opportunities. Solid waste that cannot be prevented or recycled must be treated by disposal in land filling or combustion. Land filling can be done to produce methane for energy purposes. Controlled combustion is used to reduce size of waste and produce energy [15].

Figure 2 presents a flow chart for waste management process in which products are either returned back to be reused as new products or turned into green energy to be used for human requirements.

Implementation of sustainable waste management practices requires an understanding of different social, economic, and legal/regulatory issues involved, such as:

- **Institutional level:** Establish a national policy and pass laws on solid waste management standards and practices.
- **Social level:** Encourage citizen participation in all phases of waste management planning to help gain community awareness, input, and acceptance.
- **Economic level:** Calculate the initial capital investment requirements and long-term operating and maintenance costs associated with the various waste management activities.
- **Technical level:** Include geological factors, transport distances, and projected waste generation in siting and design considerations.
- **Environmental level:** Establish procedures to verify the protection of groundwater and drinking water.

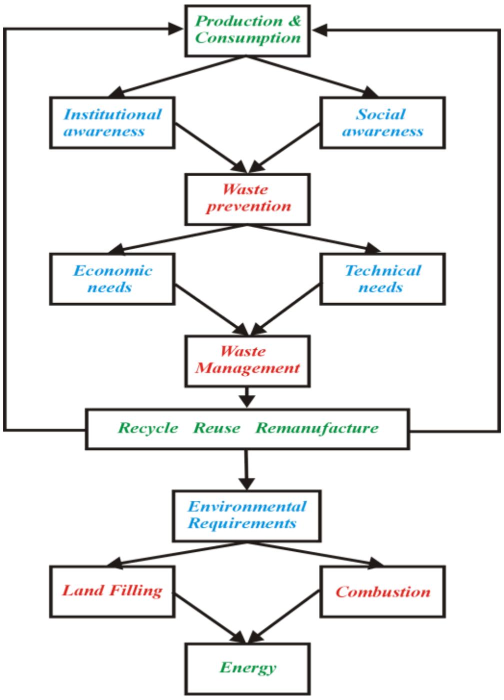

Figure 2: Waste management flow chart

3 EDUCATION AND TRAINING

MENA societies need solutions for resource efficiency to attain different national goals for sustainable development. Exploitation of the synergies across the societies: higher education institutions, NGOs, investors and professional bodies are likely to bring resource efficiency to practice. Education is fundamental to the achievement of the resource efficiency, therefore modernization of engineering education and lifelong learning training is needed.

3.1 Innovative education methods

Higher education is considered as one of the most important reasons for emigration from MENA to Western countries. In order to avoid this brain drain, it is necessary to improve higher education system in the MENA including employing new modern learning techniques. The modern learning theory states that "Student is the centre of learning process while teacher is just a facilitator". Figure 3 presents the distribution of MENA students abroad. It is clear that the majority of students is distributed amongst the EU countries.

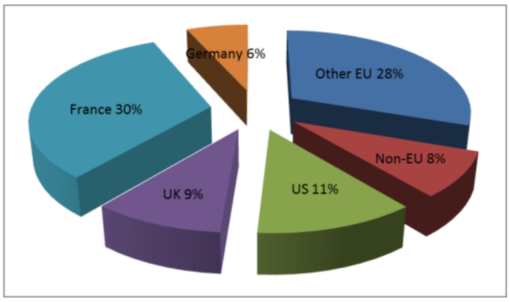

Figure 3: Distribution of MENA students studying abroad (Source: UNESCO 2008).

Project Based Learning (PBL) is considered as one of the best methods for engineering education. PBL is based on using practical projects on which students work in groups to implement scientific theories on real problems. Here, students are divided into groups where each group works on a specific project or problem to be solved. Problems are selected to solve problems facing local society. Community Based Learning (CBL) is another learning technique based on integrating students into local community and reflecting the impact of education on this community. CBL can be applied on engineering education as well as other scientific and humanity disciplines.

Cooperative (CO-OP) education is considered one of the most important learning methods for Engineering, Information Technology and Business educational disciplines. CO-OP can be divided into two main techniques: In-class cooperative learning and in-market cooperative learning. It helps students to share ideas and opinions, ask for reasoning, work in teams, encourage everyone to participate and energize groups. On the personal level, it leads students to learn monitoring, observing, intervening and processing [16]. In-market CO-OP learning aims at developing partnership with local market and industry and opening new opportunities for students and graduates in their future career and business.

3.2 Lifelong Learning

Lifelong learning (LLL) is a very wide concept and has been defined by different people depending on the national context. It can involve the following forms: adult learning; non-traditional students in a formal and informal environment; supplementary (non-degree) study programmes; career reengineering programme. The activities carried out under LLL can vary from part-time, distance, adult, mixed-mode, electronic and open learning. Lifelong learning can be provided either by HEIs or by private professional associations. Nevertheless, it is required from the governments to lay out rules and measures for the implementation of LLL in the frame of cooperation between higher education and industry [17].

4 3.3 RESOURCE ACCOUNTING PERSPECTIVE FOR ENGINEERING EDUCATION

This paper presents a newly developed model for engineering education. The proposed model for engineering education is based on the Integrated Definition Function (IDEF) Modelling technique. The engineering education model shown in Figure 4 is based on considering "Engineering Education" as the main function to be modelled. This function is supported mainly by six variables: inputs, outputs, controls, mechanisms, information and dynamics. These variables are connected as follows:

Outputs: The main outputs of the engineering education process are: Knowledge - is the most important output on which most of other outputs depend. Graduates - engineers from all disciplines should obtain the necessary level of education that fits to the needs of the local society. Opportunities - Having good education process leads to opening new opportunities, jobs, and business. Development - This educational technique helps in the development of local industry and society leading to improving the life level of people.

Inputs, Information, Controls & Mechanisms: The main inputs to the engineering education process are: Curriculum – Preparing curriculum for engineering programme requires taking inputs from state of-the-art literature, best practices and case-studies. To support traditional educational techniques, Cooperative education should be applied to assure sustainability. Students – are the centre of education process. Besides to theoretical information, students need to be aware of issues related to their disciplines. Assessment is used to control and evaluate the level and adequateness of these students. Students need to attend Lifelong Learning courses during and after their study period to stay up to date with all recent advances. Facilitators – In modern educational theories, teachers are called facilitators because their main job is facilitating ways for students rather than lecturing. Facilitators get their experience from global contacts with higher educational institutions and industrial partners. They transfer knowledge obtained through these contacts to the education process. The level and appropriateness of this knowledge is measured and controlled by taking feedback from local society. Resources – All previous items require resources to be accomplished. These resources are decided referring to the experimentation requirements and should be related directly to the existing resources of the local society. Resource efficiency methods should be aided here by an Open Knowledge Platform for Resource Efficiency (OKPRE).

This platform plays the role of intermediate between HEI and society.

Dynamics: The dynamics deteriorating Engineering Education process take their input from Market needs. The variables affecting these dynamics are: Theory, Research and Practice used to vary Awareness of students. The output of these dynamics is the Knowledge given to students.

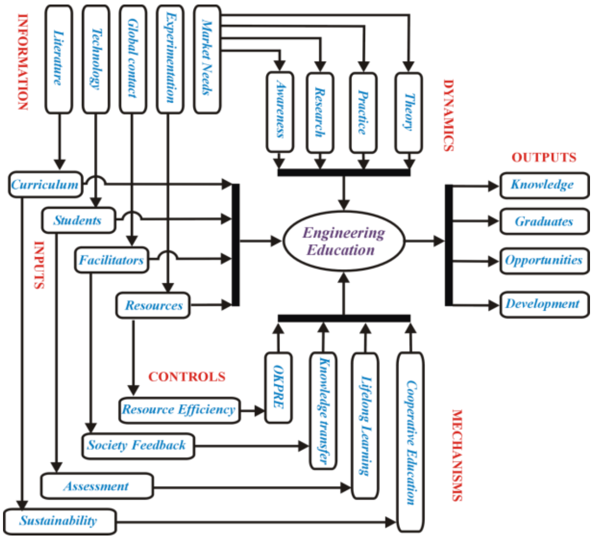

Figure 4: Developed model for Engineering Education

5 OPEN KNOWLEDGE PLATFORM FOR RESOURCE EFFICIENCY

In order to achieve a sustainable, resource efficient society, behavioral change among government authorities, private sector, organizations as well as individuals is necessary. Education is needed to promote sustainable societal behavior and enhance understanding and skills for the development of a resource efficient, sustainable society. In general, there is a wide variety of tools available to support an uptake and implementation of resource efficiency, such as [18]:

- Studies and analysis of trends in current resource efficiency and consumption and production patterns.
- Policy frameworks for stakeholder cooperation in resource efficiency.
- Economic analysis and business models for resource efficiency in the private sector.
- International expert networks and platforms, and links between education providers and policy bodies as well as government agencies.
- Capacity building tools for sustainable management, operations approaches and product choices for governments, civil society organizations, etc.

Education is one of the key elements to achieve a resource efficient society, therefore a tool that facilitates information exchange, knowledge assessment, raising awareness and an adoption of best practices is needed. This is addressed through the Open Knowledge Platform for Resource Efficiency (OKPRE). The OKPRE is a digital forum, ICT open data knowledge hub combining open social media, distributed knowledge creation and sharing tools in order to create new and innovative practices of resource efficiency.

6 RAISING AWARENESS

Raising awareness will be partially incorporated into the OKPRE to drive the transformation of markets and to ensure a gradual adoption towards resource efficiency. The needed transformation requires an open exchange of ideas among students, interdisciplinary researchers, enterprises, business executives, and the public. To raise awareness and gain impact, a forum for multi-stakeholder participation, dialogue, exchange of experience, best practices and partnerships for resource efficiency will be incorporated to OKPRE with the aim of making awareness open and hence more accessible to a broad base of stakeholders in Occupied Palestinian Territories (OPT) and the wider MENA region, covering public institutions, private sector and civil society. The following steps may offer a way forward for developing an outreach for resource efficiency:

- Conducting needs assessment: Awareness actions are most likely to succeed if they are developed in cooperation with major stakeholders and individuals from society at large to complement governmental development strategies.
- Developing national/regional resource efficiency awareness actions: The major issue in this step is to implement what needs to be achieved (as per identified needs) and how to engage partners and stakeholders in a broad and open effort.
- Dissemination through workshops for stakeholders: Dissemination should communicate the findings of the needs assessment; agreed list of priority activities; recommendations for implementation; and produce a strategy paper (published action plan) for establishing resource efficiency awareness program.
- Implement priority activities: In the case of raising awareness, activities may range from web and radio/TV programs and launching PR campaigns.
- Strengthen and sustain the outreach: Sustainability is always a major challenge for outreach programs. Funding and collaborative partnerships need to be maintained over the longer term.

Another imminent approach is to share and analyze the feedback of the novel, even though regionally focused, resource efficiency approaches to engineering education within international forums, such as this conference.

7 CONCLUSIONS

This paper discussed engineering education in the MENA region with the focus on integrating resource efficiency knowledge in this process. Statistics about water and energy problems in the MENA region were given for case studies from Palestine. Proposed solutions for waste management and material management were discussed and demonstrated. Novel techniques of engineering education was debated, concluding that using new educational strategies like CO-OP, Problem Based Learning and Lifelong Learning can lead towards more sustainable society. A new educational model based on IDEF modelling technique was depicted. This model involves most of the necessary inputs, outputs, mechanisms, controls and information required for the advancement of educational process. The dynamics shown in the model represent the factors that deteriorate the learning process and its influence on the level of knowledge obtained. The OKPRE was introduced to support practices for sharing educational knowledge, to achieve changes in production and consumption patterns, and to raise awareness regarding resource efficiency through open access approach.

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