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# EDUCATION IN VALUES IN ENGINEERING. ENERGY FOR HUMAN DEVELOPMENT AND SUSTAINABILITY

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**Key words:** Energy, Human Development, Education in Values, Sustainability.

**Summary.** Energy is central to achieving the interrelated economic, social, and environmental aims of sustainable human development. This paper relates some UPC efforts to introduce the sustainable energy concept in its engineering curricula. The UPC approach is based on the education in values, the critical analysis of the present paradigms, and an overview of the global South reality under a human rights-basis.

## 1 INTRODUCTION

In Agenda 21 the United Nations and its member states have strongly endorsed the goal of sustainable development, which implies *meeting the needs of the present without compromising the ability of future generations to meet their needs*. Sustainability has been also defined as "design of human and industrial systems to ensure that humankind's use of natural resources and cycles does not lead to diminished quality of life due either to losses in further economic opportunities or to adverse impacts on social conditions, human health and the environment"[1]. But current energy systems, as analyzed in this paper, are not addressing the basic needs of all people, and the continuation of business-as-usual practices may compromise the prospects of future generations.

The current energy system of industrialized countries is heavily dependent on fossil fuels, which are geographically concentrated in a few regions of the world. On the other hand, although energy's potential for enhancing human well-being is unquestionable, conventional energy production and consumption are closely linked to environmental degradation. Additionally, emissions of anthropogenic greenhouse gases, mostly from the production and use of energy, are altering the atmosphere[2].

The world energy supply model based mainly on the consumption of non-renewable energy sources, also on polluting technologies and on end-use energy waste, doubtlessly is questioned by environmentalist and sustainability defenders. Finding ways to expand energy services while simultaneously addressing the environmental impacts associated with energy use represents a critical challenge to humanity[2]. During the World Summit for Sustainable Development (Johannesburg, September 2002) an agreement was reached that significantly advances the attention given to energy by the international community in the context of sustainable development[3].

In this context, some universities promote the inclusion in their curricula of cleaner technologies and technologies that take advantage of the energy sources known as "renewable". For instance, since 2000, a European Master's program is offered in renewable energy. The aim of the European Master in Renewable Energy is to provide post-graduate students able to fill the gap between the growing industry demand for specialized renewable energy expertise and the skills available in the jobs market[4]. The program focuses on technical and economic aspects of renewable energy sources. There are several partner universities where each one trains students in one specific renewable technology. More recently, the Universitat de Barcelona and the Universitat Politècnica de Catalunya, in a joint initiative, have launched a Master on Energy Engineering[5]. This course aims to provide solutions to today's energy problems in several different areas: resources, production technologies, transport and energy distribution, environmental impact, efficiency, savings, rational use, among others. Students are expected to acquire the necessary knowledge and skills to analyze practical examples and manage generation, transformation, distribution and consumption projects involving various energy sources. On finishing the Master's Degree, graduates will be able, among other skills, to manage projects for the use of renewable energy, and participate in R&D in technology companies in the energy sector.

But technology is not the single problem in the path to sustainability, nor the single response needed. Universities can fall in a reductionist technological approach, pushing technological changes without going beyond. Engineers of the 21st century need to have an adequate understanding of how industrial, political, economical, and societal actions impact the environment in which we live or how today's activities may impact future generations. As a result, there is a considerable need for increased knowledge and awareness of the issues surrounding sustainable development. Engineers are required "to evaluate the implications of their solutions beyond their immediate technical context"[6]. In this sense, the sustainable approach of some curricula allows the future technologists to have a holistic vision during their formation process[6, 7].

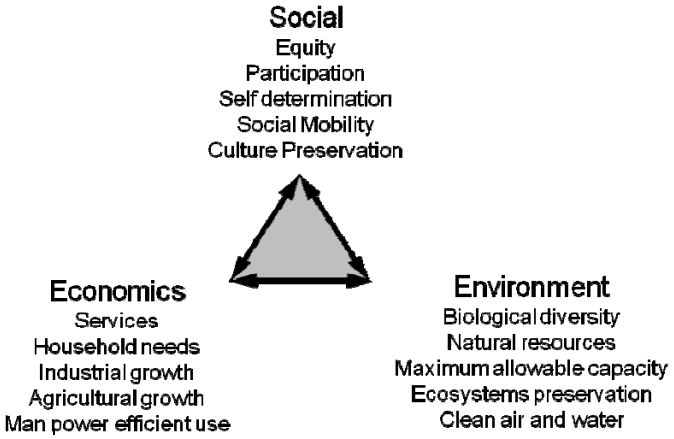


Figure 1: Sustainable development is a balance between social, environmental and economic objectives.

At this point, it is necessary not to reduce the concept of sustainability to a purely environmentalist approach. Experts from international organizations such as the United Nations Development Program (UNDP) suggest that sustainable development is a balance between social, environmental and economic objectives (Figure 1).

When applying the "sustainable" adjective to the energy concept, we are talking about: "energy produced and used in ways that support human development in all its social, economic and environmental dimensions" as defined by the UNDP's World Energy Assessment[2]. This supposes to extend the point of view with which the technical solutions and policies for the production and use of the energy are considered, including not only the future generations, but also the present generation in developing countries[2, 3, 8, 9, 10]. As said UNEP Executive Director, Achim Steiner, during the CSD-15 meeting: "As it becomes increasingly apparent that climate change is the major crisis facing us all, it's also clear that we have to provide clear energy solutions to solve the critical problem of energy access in developing countries, particularly those in Sub Saharan Africa."[11].

In the analysis of the world energy system under this context we can point out some aspects like, for instance, its social unsustainability. Some key factors are[8].

- The inequalities in the access to energy between North and South people.
  Approximately, 1 of each 3 inhabitants of the planet does not have access to modern energy services (about 2,000 million people)[12], which limits its opportunities of development and its access other basic services like clean water, health, and education.
- The global and local environmental and social impact of the exploitation and utilization of fossil resources, mainly by the industrialized countries.
  Paradoxically, having fuel resources -as petroleum and natural gas- has become a "misfortune" for some countries in Africa and Latin America, which suffer of environment impacts, political pressures, and/or social instabilities[9].
- The impacts of global warming and climatic change.
  This will have the worse repercussions in developing countries due to their larger vulnerability to these changes[9].
- The impact of the increasing price of oil on the weakest economies.
- The geopolitical conflicts derived from the will of rich countries to control oil resources.
- The social and environmental impacts that can produce an increasing demand of bio-fuels by industrialized countries on the developing countries[13].

Therefore, the model of development of the industrialized countries and their huge associated demand of energy, have a considerable impact on the impoverished countries that indeed are those that do not have access to energy and opportunities for sustainable development. When evaluating the implications of our technical solutions beyond our immediate technical context in the energy field, therefore, we must take into account what are the impacts in the developing countries. By acting now to embrace enlightened policies, we can create energy systems that lead to a more equitable, environmentally sound, and economically viable world.

On the other hand, engineers have been accused for a long time of neglecting the social

consequences of their work. Nevertheless, the standards for acceptable engineering practice are evolving to increased focus on ethics[14], [15], and several efforts have been done by some Spanish educational institutions in the past few years to introduce the principles of Education for Human Development in engineering curricula, also issues related to the Cooperation for Human Development[9], [16], [17].

When locating the energy technologies within the framework of Human Development, we are talking about harnessing the mechanisms and strategies that allow that certain technical solutions dignify and improve the life of people[11]. As UNDP states in its 2001 Human Development Report *Making new technologies work for human development*,

- People all over the world have high hopes that new technologies will lead to healthier lives, greater social freedoms, increased knowledge and more productive livelihoods;
- The 20th century's unprecedented gains in advancing human development and eradicating poverty came largely from technological breakthroughs;
- In the network age, every country needs the capacity to understand and adapt global technologies for local needs; and
- Policy, not charity, will determine whether new technologies become a tool for human development everywhere.

It is under this approach that the UPC, with the support of Engineers Without Borders Catalonia (ESF), has performed an educational curriculum in *Energy for Human Development and Sustainability*, which is based on the education in values, the critical analysis of the present paradigms, and a closer view of the global South reality, as well as on the study of appropriate technologies.

## 2 ENERGY FOR HUMAN DEVELOPMENT AND SUSTAINABILITY COURSES

The first courses implemented at the UPC in Energy for Human Development and Sustainability where in the form of free-choice subjects[18]:

- *Engineering and Human Development: Renewable energies* (ETSEIB), academic years: 03/04, 04/05, and 05/06;
- *Applications of renewable energies in cooperation for development* (ETSECCPB), academic years: 05/06, and 06/07;
- *Biomass as energy resource in developing countries* (ETSEIB), academic years: 05/06, 06/07, and 07/08.

The UPC also recognizes free-choice credits to students following the online ESF courses[19]: *Energy and Cooperation for Development* (50h) and *Projects for energy supply in rural communities* (50h).

At present, work is progress to incorporate these subjects in several UPC's official masters, as follows:

- Official Master in Sustainability. Subject: *Basic services and development in economically depressed rural areas*. One third of the 5 ECTS subject is dedicated to the supplying of energy in rural areas of developing countries.[20]
- Official Master in Agriculture for Development. The subject is also *Basic services and development in economically depressed rural areas*.

- Official Master in Biotechnology. Subject: *Biogas and waste treatment.* The chapter *Biomass as energy resource in developing countries* will be introduced like a part of the subject agenda.

## 3 EDUCATION IN VALUES

The objectives of these subjects are not purely informative, nor exclusively student's awareness rising oriented. One of their fundamental objectives is the education in values. Energy is studied under a human rights-based approach.

The world energy scenario is analyzed using ethical principles, mainly in reference to the inequalities between North and South, and in the impact of the prevailing energy model on the most underprivileged people. During the training process, critical thinking is also promoted by means of group dynamics, where the students should discuss on the appropriate solutions to be applied in several case studies or discuss about policies on the energy sector.

An effort is made to bridge the gap between sound technical and economical design and the people and environment that should ultimately benefit from engineering[10].

## 4 BREAKING MYTHS ABOUT TECHNOLOGY AND ENERGY

These courses also are focused to break old myths, like for example:

| Old myths | Realities |
|---|---|
| Technology transfer is a process that always goes from the North to the South. | False. Some authors already speak about "sharing" technologies, more than transferring them. In the international framework, the South-South technology transfer is already a reality. |
| Northern Technologies are directly applicable in the South. | False. The main error of the international cooperation in the past has been not to adapt the technologies to the local contexts. |
| Technology (infrastructures and knowledge) is the only aspect to be considered in an energy supply project. | False. The success of a project is also linked to questions like cultural values, participative approach, and organizational processes, as well as to people capacity development, among other social issues. |
| The energy supply by itself generates development opportunities, and energy bottlenecks and solutions impact men and women in similar way. | False. Access to energy is a necessary but nonsufficient condition. It is necessary to apply a holistic approach of the development to generate significant impacts and to avoid increasing inequalities, for instance, between men and women. |
| Renewable energies are always "sustainable" and the only acceptable alternative. | False. In the past decades, the international cooperation has generated a lot of fiascos on projects based on renewable energy. Lessons learned in the past must be rigorously reviewed to avoid falling into idealisms or wrong approaches. |

Table 1 : Myths and realities about technology and energy supply in developing countres.

Following these principles, only a fraction of the course's agendas, approximately a half part of the time, is related to the technological aspects. Students are introduced to subjects like: Human Development, Technologies for Human Development, North-South Inequalities in the energy field, the role of energy in the fulfillment of the Millennium Development Goals, Policy of the international institutions; and in subjects that some authors designate as the "soft aspects of the technology", like for instance: participative processes, capacity development, management of stand-alone energy systems, electricity tariffs for rural communities, technology transfer, finance mechanisms, and gender perspective. A special emphasis is made in the social sustainability of projects in developing countries, also on the integrated approach recommend by the UNDP for energy projects and polices[15].

In the part of the agendas dedicated to technology ("hardware aspects"), those energy technologies better adapted to the socioeconomic context of the isolated rural communities in developing countries, or those technologies specifically developed to be applied in this context, are considered.

In the generalist courses, thermal and photovoltaic solar energy, micro hydraulic energy, micro wind energy, and biomass technologies are studied. In the course specially dedicated to biomass as energy resource, technologies that take advantage of bioenergy like improved traditional technologies or "advanced technologies" (biofuels, gasification, heat & electricity cogeneration, and anaerobic digestion) are studied. In all courses, the negative impacts of the traditional use of biomass in developing countries are included.

It is important to observe that these courses cover the three areas covered by the sustainable energy concept (Figure 1). For example, the courses combine the technical evaluation of renewable technologies with an assessment of energy demands. This is an example of how assessing the need (energy services) of a particular group (social) is coupled with selecting the correct technology (environment) by evaluation project financing (economics). Engineering students are required to consider non-technical issues that are often more important for project analysis.

## 5 APPROACHES TO THE SOUTH REALITY

Depending on the characteristics of each course, different instruments are used:

- Volunteers from Engineers Without Borders facilitate some group dynamic works and/or expose some experiences in the projects carried out by this NGO.
- Some invited dissertations and conferences are given by external experts.
- A problem-based learning approach is also used[6]. Students are presented with complex, ill-defined problems in order to develop skills and to stimulate students to have a better knowledge of the South reality.

This methodology aims the students having a direct transmission of the experiences of people and organizations with field experience in the application of the concepts learned during the course.

## 6 FUTURE OPPORTUNITIES

### 6.1 Field work

The integration of *Energy for Human Development and Sustainability* in several UPC's official master courses is opening the opportunity to carry out master thesis in this area. Additionally, the university support to student's mobility (by the UPC's Center of Cooperation for Development – CCD), opens the opportunity to carry out field studies in developing countries as a part of the master thesis work program. This action would extraordinarily multiply the capacity of the university for knowledge generation, to transform the environment, and to train the future actors of social changes.

### 6.2 Practical workshops

Another opportunity for the future is the organization of practical workshops on some of the studied technologies, for instance, micro wind systems for electricity generation or small-scale biogas generators. The necessary infrastructures are relatively inexpensive, and should also allow the benefit of the practical learning, also the approach of Northern citizens to alternative household energy technologies.

## 7 CONCLUSIONS

Energy is central to sustainable development and poverty reduction efforts. It affects all aspects of development -social, economic, and environmental- including livelihoods, access to water, agricultural productivity, health, population levels, education, and gender-related issues. Therefore, a holistic approach, and an increased focus on ethics and human values must be included in the engineering curricula.

The traditional role of the engineer as an analyst and builder can evolve to act also a lobbyist for changes. Therefore, it is not only engineering that an engineering student must learn and understand. An engineering student must also comprehend other aspects of sustainable energy development.

As stated by the WFEO mission[22]: "Engineering is the art of using science and technology, traditional experience and creativity, for the benefit of humanity. The engineering profession is a major contributor to the quality of life, welfare and wealth of the people of the world". This is the objective of the UPC training program on *Energy and Human Development and Sustainability*, to educate engineers for the benefit of mankind, and to contribute to the quality of life of human beings.

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