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IRAN ENERGY ASSOCIATION

German-Iranian Co-operation VI

"Development of three cornerstones for a sustainable Energy future in Iran "

Work package 3.

Energy Education Programs; A Comparative Study in Iran and Germany

Final Paper

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Authors:

WI:
Dr. Stefan Lechtenböhmer
Magdolna Prantner
Dieter Seifried
Dr. Nikolaus Supersberger

IEA:
Dr. Saeed Moshiri
Dr. Farideh Atabi
Prof. Mohamad Hassan Panjeshahi

Wuppertal Institut für Klima, Umwelt, Energie GmbH
Döppersberg 19
D-42103 Wuppertal

Table of Contents

Table of Figures

1. Introduction

Iran is an energy rich country and its economics has been highly dependent on energy revenues for a long time, but energy education in general and particularly in universities in the country is rather new. Rapid growth in energy consumption and government's fiscal limits to continue with the energy subsidy programs has recently led government to undertake a public awareness campaign through media encouraging energy conservation by households[1]. On the formal education level, some universities have started to offer programs in energy since 2000 when the energy programs were officially approved by the Ministry of Science, Research, and Technology. With oil and natural gas driving almost all economic activities, the university programs are primarily focused on those resources offering courses which cover technical issues in different engineering departments. Lack of human resources in energy economics has also led universities to offer courses and programs in the areas of management and economics of energy. The formal education programs have been rapidly developing in universities since 2000. There are now various programs in energy engineering at different undergraduate and graduate (MEng/MSc and PhD) levels offered by some large technical universities. Moreover, some universities offer courses and programs in energy economics at MA and PhD levels. Islamic Azad University, as the largest private university in Iran, has been also active in developing energy programs at undergraduate, graduate and PhD levels in its Science and Research branch.

Germany is one of the developed countries that has made an aggressive investment in renewable energies and developed extensive educational programs in different levels. This can be seen in the context of the country being highly dependent on energy imports and the same time in forefront of technological progress. Government policies in general support investments in renewable energies and private sector has been actively participating in various renewable energy development projects. Along with the physical investment, Germany has also developed university programs and research institutes to provide the knowledge and the skills required for the renewable energy programs. Therefore, a review of the renewable energy education programs in Germany can be useful for other countries.

In this paper, we briefly review higher education programs at different levels in the areas of renewable energies in Germany and Iran. The paper is organized as follows. In section 2, the importance of renewable energies for developing countries is discussed. In section 3, the education programs in Germany and in section 4 the programs in Iran are reviewed.

[1] For example, the Ministry of Energy and National Iranian Gas Corporate (NIGC) produce video clips and broadcast in the national TV channels to encourage energy conservation particularly during the peak consumption periods in summer and winter.

2. Why developing countries should join the renewable energy revolution?

Renewable energy and energy efficiency have become of great interest in recent years as countries become increasingly concerned about energy security, rising electricity prices and climate change. Energy scenarios released by various agencies indicate that in the medium to long-term, renewable energy will play a crucial role in the global energy mix. For instance, according to the International Energy Agency's World Energy Outlook (2008)[2], increases in electricity generation from renewable sources in the OECD are set to more than double the combined increase in fossil fuel and nuclear generation by 2030; output from wind power is projected to increase seven-fold over the same time period; and constant price decreases in solar power will make these technologies increasingly attractive. As Figure 1 shows, that the turnover for renewable markets, energy efficiency and other "green markets" is growing at an enormous rate per year.

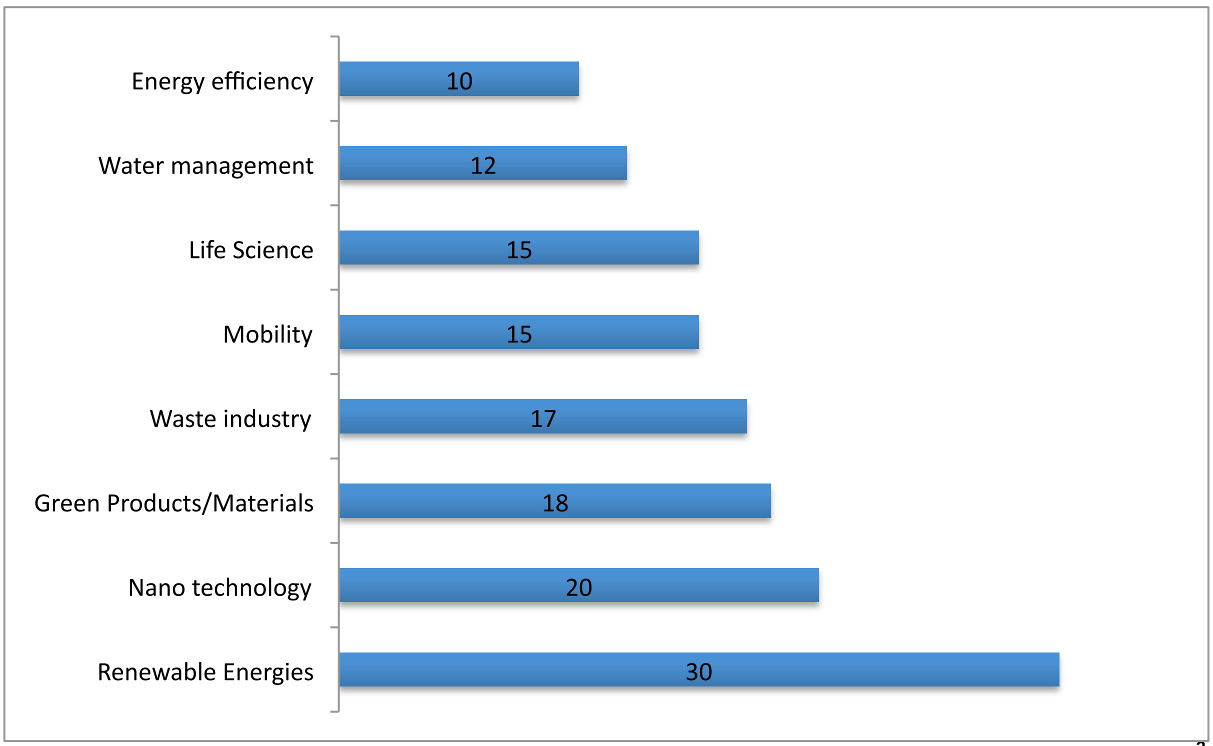

Figure 1: Growth rate of different markets for environmental technologies in the year 2005 (%)[3]

In 2009, the German PV industry had a turnover of over 10 billion Euros and employed over 64,000 workers[4]; whereas the wind industry employed over 100,000 workers and achieved a turnover of more than 8 billion Euros[5]. These figures gives an indication of the important role

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[2] http://www.worldenergyoutlook.org

[3] Source: Roland Berger Unternehmensbefragung 2006 (Expertenschätzungen)

[4] Germany Trade & Invest. PV Industry. Accessed August 23, 2010. Available at: http://www.gtai.com/homepage/industries/renewable-energies-resources/pv-industry/

[5] German WindEnergy Association (BWE). Wind Energy in Germany. Accessed August 23, 2010. Available at: http://www.wind-energie.de/en/wind-energy-in-germany/

renewable energy can take in terms of job creation and contributions to gross domestic product. The IEA estimates (2008) that between 2007 and 2030, the cumulative investment in renewables will amount to over 5.5 trillion US dollars. Therefore, in order to take advantage of this significant market potential, countries must take proactive policy and investment decisions in order to develop their technical know-how and domestic renewable energy industries.

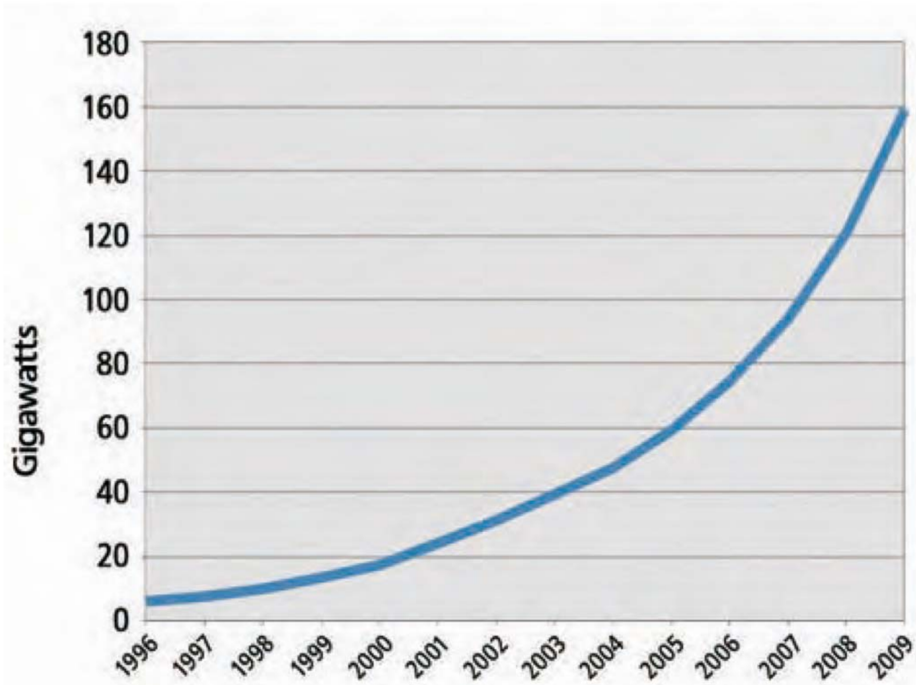

Figure 2: Wind power capacity world wide; Source: Renewables Global Status Report 2010

Until now, developed countries have largely taken the lead in terms of renewable energy development and installations; however, this trend does not accurately reflect the fact that *all* countries, especially developing countries, stand to benefit from investment in renewable energy and especially *education* in renewables. Some of the arguments in favor of renewables include:

- Reduced electricity production cost (for example at good wind sites)
- Increased energy security: reduced dependence on external energy sources.
- Decentralized generation: increases grid stability in case of failure of centralized generation plants.
- Off-grid & island systems: shorter transmission distances are practical for developing country grid systems with high distribution losses; also useful for cost-effective rural electrification.
- Access to and participation in future-oriented energy markets
- Environmental benefits: reduced CO_2 emissions and other harmful materials
- Increased competitiveness of domestic industry

Clearly, there are multiple benefits that developing countries including Iran can get from renewable energies. However, if countries desire to realize these benefits, they must not be passive regarding the slow development of their domestic renewable markets and technical know-how. On the contrary, countries that have become leaders within the renewable energy market have invested heavily in domestic industry, R&D and renewable energy education. The following section outlines the important role of renewable energy education in the renewable energy sector, and how developing countries can use education on renewables to stimulate economic growth.

Role of education

Education is central to realizing the benefits pertaining to renewable energies. All large players in the global renewable energy market have invested considerable sums in education, and this investment is critical to maintaining a competitive edge in the fast evolving renewables industry. Education is also important for supporting technology deployment through increased awareness of renewable energy and energy efficiency options. The good news is that it is not too late for developing countries like Iran to benefit from improvements in energy efficiency or to secure a share of the lucrative renewable energy market. Other developing countries like China have shown that an emphasis on education, supportive policy structure, and targeted investments, can transform countries with little to no experience with technologies in the renewable sector into major renewable sector players within a few short years.

Long-term benefits of renewable energy education

Energy savings through energy efficiency policy: given the fast growing population and the economy of many developing countries, energy demand is projected to increase dramatically in the coming years, which poses significant challenges for government and energy providers. Education on energy efficiency will have an important role to play in managing this demand. Moreover, reduced energy demand will dramatically reduce costs associated with additional capacity installation as well as grid extension and maintenance costs. As costs for energy efficiency measures are lower than the costs for the avoided construction of new power plants, an energy efficiency policy will help to reduce the costs for energy services and raise the social welfare.

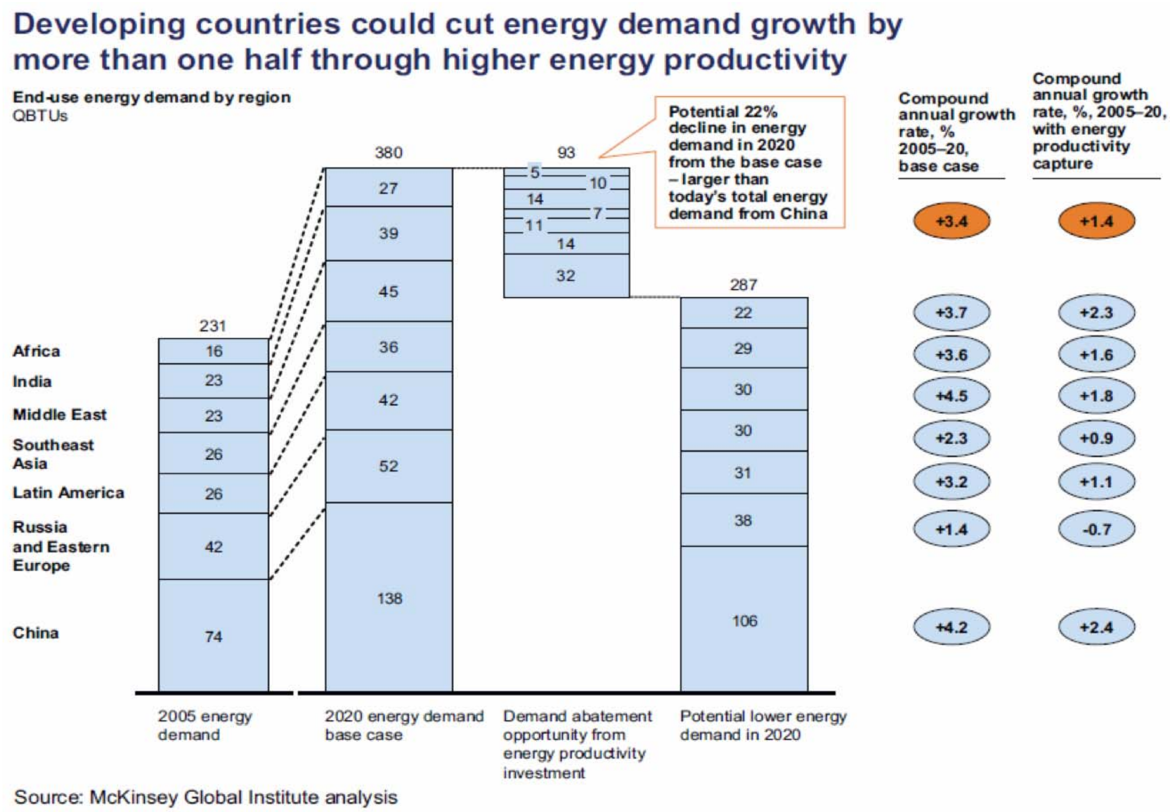

Figure 3: Energy Savings in Developing Countries

Negative CO_2e-Costs of the abatement opportunities

Wuppertal Institute (2006), McKinsey (2008) and others have shown, that many measures to improve the efficiency of buildings like better lighting, air-condition, ventilation, boilers and insulation are cost-effective and could be implemented at negative cost to society. In other words, these investments would earn a positive economic return from the savings of electricity and fuel costs.[6] The CO_2-Cost curve shows how much CO_2e (CO_2-equivalents) can be abated and at what costs. The width of the bars indicates the amount of CO_2e and the height shows the marginal cost per ton abated. The graph is ordered left to right from the lowest-cost opportunities to the higher cost opportunities.

[6] McKinsey: The carbon productivity challenge: Curbing climate change and sustaining economic growth, June 2008

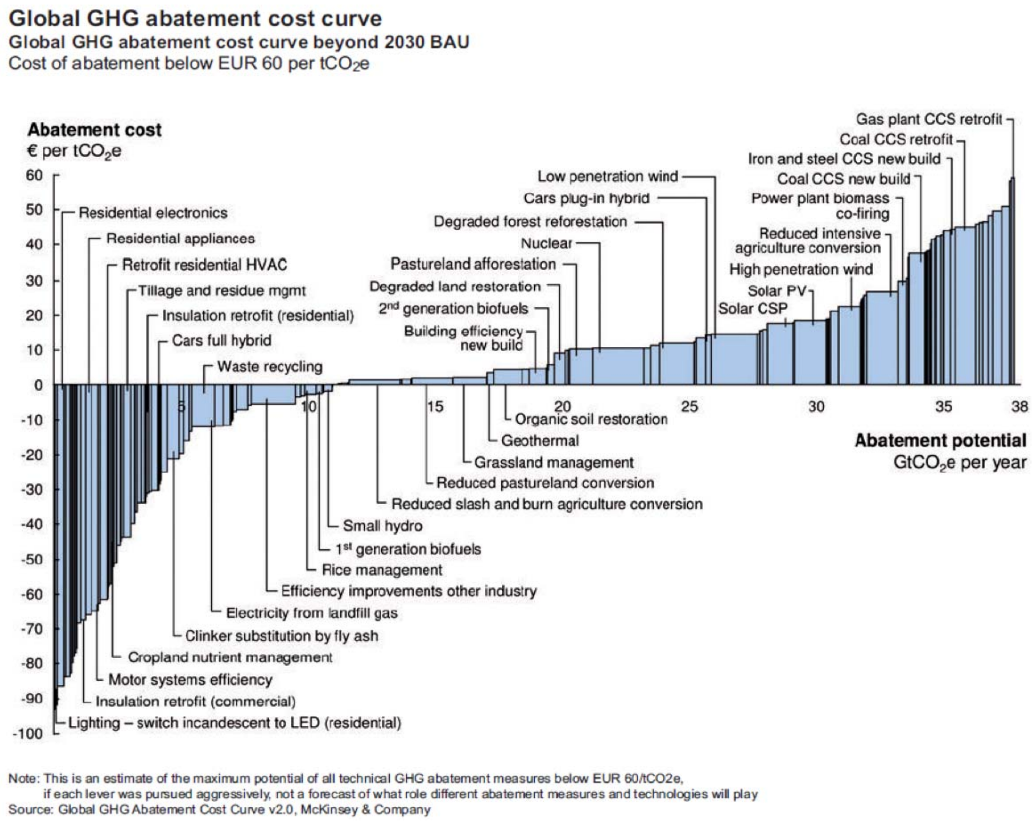

Figure 4: Global GHG abatement cost curve

A Case Study in Mexico

A project at the Mexican University UNAM (Büro Ö-quadrat, CSCP, 2009) has shown how efficiency could pay for better education in efficiency. Within a pilot project four typical university areas have been retrofitted: a foyer, a classroom, a library and a workshop. The practical, hands-on approach enabled to measure the savings and the improvement of the lighting quality as well as to find out the real cost of the retrofitting. The upgrades covered the installation of new high efficient luminaries, tri phosphor lamps, electronic ballasts, and control systems like presence detectors and daylight sensors. Together, these upgrades resulted in an average payback of less than 3 years and at the same time improved in lighting levels by more than 150%.

In a second step of the project a "master plan" for efficient lighting was developed, based on the knowledge gained from the pilot project. It showed that an investment of US$ 14 million would promise savings in electricity costs of US$ 68 million over the 20-year-lifetime of the upgraded lighting system. These earnings could be used for better education in general and for better education in efficiency subjects.[7]

[7] Büro Ö-quadrat, CSCP: Better Lighting saves money. Pilot Projection on Efficient Lighting at the National Autonomous University of Mexico (UNAM), 2009.

Energy Security

As indicated previously, education about renewable energies can help technology deployment by increasing awareness about renewable energy and energy efficiency options. Of course, the success of a technology deployment campaign (and the extent to which it would affect energy security) would also depend on the appropriate structuring of market incentives and the overall policy framework.

Competitiveness

Education is generally a wise investment option for governments aiming to stimulate the productivity and competitiveness of domestic industry. In terms of competitiveness, energy efficiency can help businesses reduce energy consumption and thus costs for a given level of product output. In this way, energy efficiency education may benefit countries like Iran by improving the competitiveness of its industries compared to the imported products from the international market. Additionally, higher-level education will help spur productivity by familiarizing the workforce with technical aspects and tools used in the renewable energy industry. The positive effects of education on productivity have already been well recognized, and an illustrative example is seen in countries from the South-East Asia region that experienced significant macroeconomic development following strategic investment in education and the high-tech sector. Further, these cases demonstrate that even developing countries can participate in high-tech areas like the renewable energy sector, and importantly, that these “home grown” industries can be an important source of national income.

Developing a skilled work force

A skilled workforce is absolutely necessary for countries aiming to increase the share of renewables in their energy mix, and education can help achieve this objective. High-tech industries like the renewable energy industry require a skilled workforce for at least two reasons: (1) expanding and supporting the domestic renewable energy market, and (2) building the domestic research capacity in the area of renewable technology in order to drive innovation and domestic competitiveness. In both cases, renewable energy education plays a central role: for example, higher education centers may be partner with industry to connect MSc and Ph. D. students with industry-relevant research topics; and naturally, industry-academia partnerships will help renewable sector businesses recruit qualified personnel through internships or work-study programs. On the other hand, partnership and cooperation with overseas research institutions and bodies (from industry and/or academia) provides an opportunity to draw in expertise and accelerate knowledge transfer.

Education in the field of energy efficiency has to be very multifaceted. The reason for this lies in the broadness and complexity of the subject. Energy efficiency relates to numerous different technology options which play a role in every part of the economy. Therefore, technologies as well as approaches for their management and implementation cover a broad field of expertise, which cannot be limited to only one specific group such as energy efficiency experts or “energy efficiency management experts”. They have to be rather implemented into the curricula of many relevant disciplines in science, engineering, and social sciences, which cover sustainable energy paths, energy efficiency technology, energy and electricity savings, climate and environment as well as energy policy programs. For example:

- For builders and architects there is a need for specific curricula as well as for motor specialists and electrical engineers.
- Dedicated energy managers should have a wide technological education combined with economic aspects, strong management skills and social competence. Energy management will play a much more important role in future as resources will get more expensive and climate change policy will become stronger.
- Policy makers in public sector need to know about different aspects of energy policies such as the effects of tax and subsidies in different areas on economic conditions and the environment.

As stated before a better education in this field will lead to lower production costs in the whole economy. It will lead to a higher competitiveness on the world market and a higher welfare of the society.

3. An overview of the energy education programs in Germany

With the growing market for renewable technologies and energy efficiency technologies, the education programs in the areas of renewable energies has also been growing worldwide. For instance, in Germany, various study programs at the Bachelor and Master levels with different focus on these subjects are developed in universities (studies). In addition, some schools and institutes offer professional and vocational trainings. Specifically, the following programs are offered by educational institutes[8] :

- Bachelor studies
- Master studies
- Diploma studies
- Dual education
- Further education beside work and distance studies

[8] http://www.studium-erneuerbare-energien.de Updated in November 2009

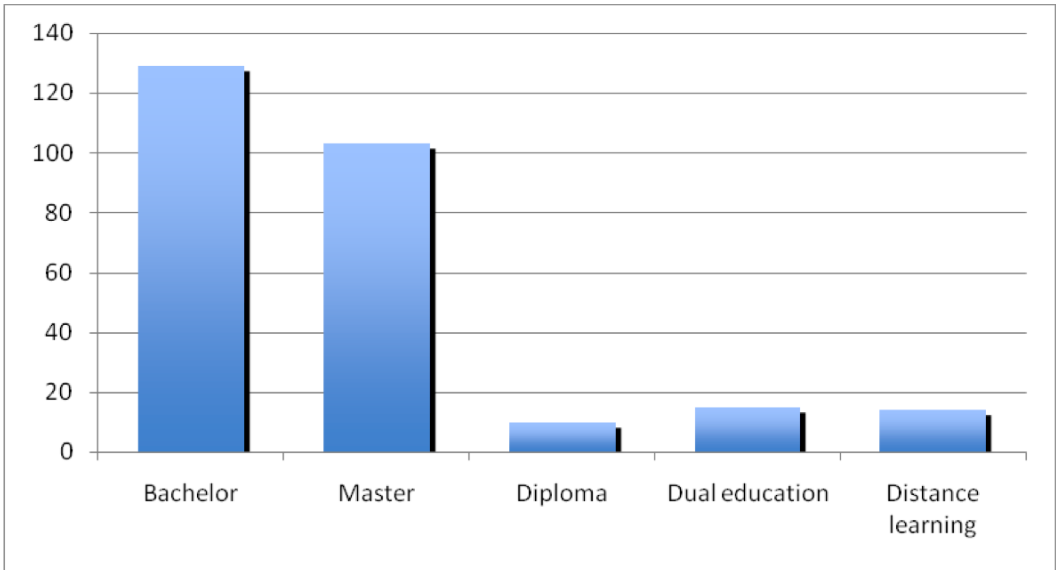

Figure 5: Overview over existing courses on renewable technologies and energy efficiency by type of studies

A Bachelor's degree gives students a professional qualification after three to four years. Admission to the second cycle, a Master's degree, depends on the student's performance in the first cycle. The Bachelor/Master's system gives students new opportunities to combine qualifications together with additional flexibility to plan their studies and professional activities.
Diploma is a traditional German academic degree, which can be compared to a Master's degree. This kind of study contains a combination of a Bachelor's and a Master's degree. The reform process of the European higher education replaces these old degree courses with the new Bachelor/Master's system.
Dual education combines vocational training after the final secondary-school examination with higher education. This form of education designed for company's staff and provides extra-occupational courses. Distance studies are another form of extra-occupational programs.
The programs are in the following categories:

- Renewable Energies
- Electrical Engineering (focus on renewable energies)
- Energy management and Energy systems (focus on renewable energies)
- Energy technologies (focus on renewable energies)
- Energy economics
- Building technologies (focus on renewable energies)
- Mechanical engineering (focus on renewable energies)
- Process technologies (focus on renewable energies)
- Environmental technologies and Environment management

Figure 6 gives an overview over the existing German courses focused on renewable energies. These are the only programs that officially have their specialization in renewable energies.

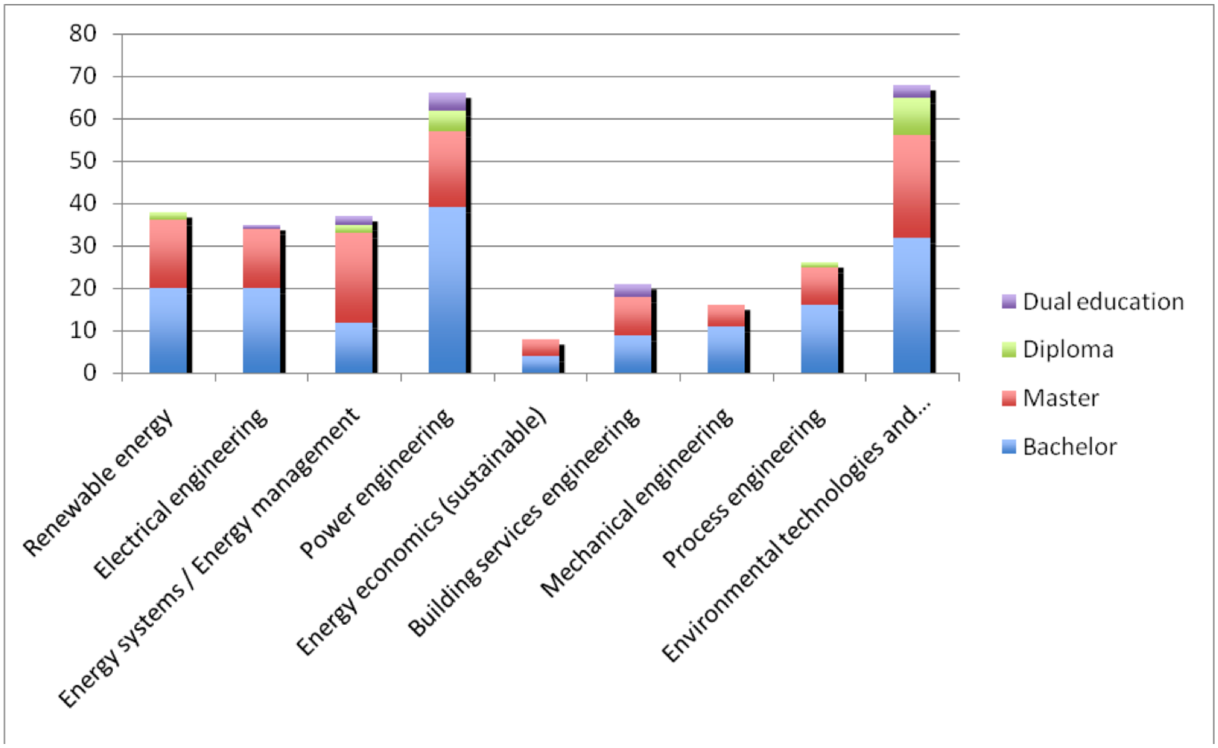

Figure 6: University programs in renewable technologies and energy efficiency in Germany[9]

In the following section we review a program offered by the University of Freiburg in more details.

3.1. A MSc Renewable Energy Management[10]

The MSc Renewable Energy Management (REM) program is offered by the Center for Renewable Energy (ZEE) within the faculty of Forest and Environmental Sciences at the Albert-Ludwigs University of Freiburg, Germany. Freiburg is home to a number of research and development facilities in the field of renewable energies as well as businesses and pilot plants that cover the whole spectrum of renewable energy technologies (photovoltaic, solar thermal energy, solar cooling, wind power, geothermal energy, wood and biomass energy), which makes Freiburg an ideal location to host the REM program.

The ZEE cross-links the partners´ applied fundamental research in the fields of solar energy, biomass, geothermal energy, energy efficiency and new energies with regard to practical research and development. In other words, one of the explicit objectives of the REM program administration is to create synergies and enable high-ranking research clusters. Another goal of

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[9] own diagram based on the data from http://www.studium-erneuerbare-energien.de/

[10] Zentrum für Erneuerbare Energien: MSc Renewable Energy Management Accessed August 23, 2010. Available at: http://www.zee-uni-freiburg.de/index.php?id=42

the ZEE is to encourage interdisciplinary research as well as interdisciplinary PhD research opportunities.

Program organization

REM is organized in cooperation with seven faculties and four external partners. As mentioned, the degree course is affiliated to the Faculty of Forestry and Environmental Sciences, however, because of the interdisciplinary focus of the study program, the team of lecturers for REM includes specialists from different areas of expertise, e.g. environmental economics, environmental policy, environmental law, environmental management and eco-systems management.

The team is reinforced by experts recruited from other faculties of the University of Freiburg, including the Departments of Forestry Sciences, Geology, Law, Medicine, Meteorology, Microsystems Technology, Philosophy, and Business and Behavioural Sciences. It will also draw on the services of outside teaching and research institutions as well as partner universities in Germany and abroad.

REM Program

The concept of the M.Sc. course “Renewable Energy Management” is based on the following fundamental considerations:

- The course enables students to avail themselves of innovation in the field of renewable energy and to implement the concept of sustainable development for practical business purposes.
- Technical know-how and an awareness of societal problems are necessary qualifications; however, additional management qualifications are required. These include technical knowledge, multidisciplinary ability in terms of team development, presentation and project management.
- The degree course is practical and problem-focused (projects, case studies, internship, a Master’s thesis on practical and relevant themes carried out in cooperation with industrial partners).

REM Aims and Target Group

REM students acquire the knowledge, methods and skills necessary for “Renewable Energy Management”. Coursework focuses on:

- Technological principles
- Climate and energy policy
- Environmental economics and environmental management
- Principles of the social, behavioral and legal sciences
- Ethics
- Specialization in the field of biomass, energy efficiency, geothermal energy or solar energy.

Students completing the course have the ability to plan projects and facilities for the utilization of renewable energy, and to implement them while taking account of economic, political and societal concerns. The course aims to give students the capacity to initiate, implement and evaluate the necessary negotiation and decision-making processes in a contextually sensitive way, i.e. in respect of both structure and culture.

REM Characteristics

The main characteristics can be described as followed:

- REM is designed to close the strategic gap between the numerous courses providing training in the technical aspects of renewable energy and the environmental courses geared towards sustainability.
- The course is taught in English only to small groups of exceptional international students meeting international quality standards.
- REM is not composed deductively from existing university structures and study programs, but inductively from analysis of the potential, international employment market and the qualifications it requires.
- With regard to course composition and discipline, the Albert-Ludwigs University of Freiburg, in close collaboration with its partners in local teaching and research establishments provide a comprehensive understanding of modern sustainability.

REM Curriculum

- The course enables successful students to avail themselves of innovation in the field of renewable energy and to implement the concept of sustainable development for practical business purposes.
- The REM coursework is taught in three week modules, which offers the possibility for concentrated work and the integration of a range of teaching techniques.

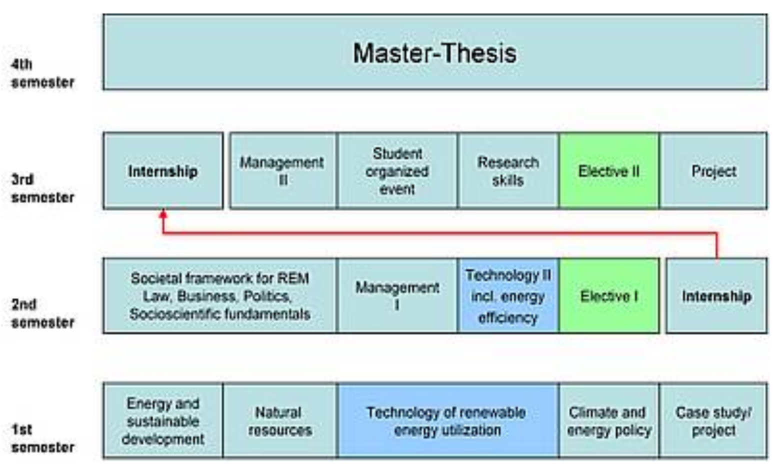

Figure 7: The curriculum plan for the master course of renewable energy management[11]

[11] Source: http://www.zee-uni-freiburg.de/index.php?id=42

- Students completing the course have the ability to plan projects and facilities for the utilization of renewable energy, and to implement them while taking account of economic, political and societal concerns.
- A fundamental aim of the REM degree course is to train students to acquire practical skills. These skills are attained in the course of project work, internships and through work on practical and relevant themes as part of the MSc-thesis.

Block modules
Building on good experience, the “Renewable Energy Management“ coursework is very concentrated and is taught in three week modules. Students do not have to listen to conventional lectures from only one tutor, but instead are taught by teams of lecturers recruited from different departments. Structuring the curriculum into modules offers the possibility for concentrated work and the integration of a range of teaching and learning techniques (role play, papers, team work in small groups).

Student organized events
The students themselves are responsible for planning and staging events like an international workshop, a conference etc. Topical questions related to “Renewable Energy Management” are selected by students at the beginning of the study program and are applied in a creative manner; students receive support from the lecturing team for choosing their topic as well as for planning and presenting their event.

Career Prospects
The REM program has identified career prospects affiliated with the REM course and by contacting selected companies and institutions from trade, industry, and from the renewable energy sector in particular. An analysis of the potential employment market shows that substantial career opportunities exist for REM students.
Upon completion of REM, graduates acquire extensive technological know-how combined with excellent practical management skills. Thus REM students are well prepared for employment in a variety of fields:

- Renewable energy companies
- Power supply companies
- Financing and Investment companies specializing in financing environmental projects, as well as investment and development banks
- Planning and Engineering companies
- Consultancy and information services (energy agencies, technology transfer institutions) and public relations
- Project Management

3.2. Content of one of the basic modules

Technology of Renewable Energy Utilization I[12]

1. **Introduction in thermodynamics and instrumentation and control**

- Thermodynamics: the course repeats thermodynamic basics, i.e. describes basic concepts and definitions, explains the first law of thermodynamics (energy conversation) and its application, and gives a brief overview about properties of gases and liquids. Finally, a short introduction to the second law of thermodynamics is given whereby also heat transfer problems will be touched.
- Instrumentation and control: Students will learn about common laboratory instruments (signal generators, frequency counters, oscilloscopes, spectrum analysers) and signal processing and control software (Lab View and Matlab/Simulink). Sensors and common analog signal processing circuits will also be reviewed and many of these tools will be used and demonstrated in laboratory exercises using robots controlled by computers. Students will also be introduced to formal signal processing and control theory, using methods of engineering analysis.

2. **Thermal conversion technologies**

- The course covers energy conversion technologies based on thermal processes. First, an overview on technologies widely used in the energy sector for conversion of fossil fuel is given.
- Following that technologies fitting to smaller scale decentralized power plants applying primary energy sources like biomass (solid wood, wood chips, and pellet operated power stations), solar energy and waste heat as well are treated.
- Some representative applications of such power plants are examined in detail and the basic design considerations and design rules are studied.

3. Renewable energies

- Basics of solar cell principles and characterisation, cell technology, simple design of photovoltaic systems and calculation of energy gain.
- Flat plate and vacuum tube solar collector design; black and selective absorbers, background of radiative and convective heat transfer and optical gains in solar collectors;
- system concepts solar domestic hot water, solar assisted heating; hot water storage; low and high flow solar systems.
- Concentration of solar radiation; concentrating collectors for high temperature applications;
- Different types of solar power systems (parabolic trough, linear Fresnel, solar tower, dish systems);
- Principles of solar power stations using steam turbines.
- Harvesting and logistics of biomass: knowledge about different biomass harvesting techniques. Importance of harvest and transport logistics for the profitability of biomass utilisation.

[12] Excerpt of the Modul Handbook REM 2009/2010

- Introduction into logistic optimisation techniques.
- Bio-energy fuel products: an overview on production technologies, existing quality standards, and the energy efficiency of bio-energy fuel products.
- Thermal conversion and power generation: focus will be on the energy efficiency and eco-balance of thermal conversion and power generation.
- Conversion of biomass to liquid fuel (BTL): the basic principles of the technology of conversion will be explained and energy efficiency compared with other biomass utilization systems.

The renewable energy industry has grown dramatically in recent years, and projections indicate that this trend will continue well into the future. Developing countries need to take aggressive action if they wish to participate in this sector; by integrating renewable energy and energy efficiency into school curricula; creating dedicated higher-education centers; and fostering industry-academia partnerships, developing countries will be well positioned to become important market actors in the area of renewable energies, as well as benefit from increasing domestic productivity, competitiveness, and national income.

4. An Overview of the education programs in Iran

The Iranian universities have recently developed programs in energy studies at different departments at both undergraduate and graduate levels. The majority of the programs are in engineering areas offered by the technical universities in Tehran and few in energy economics offered by the economics departments. The private Islamic Azad University has also become active in offering programs in the areas of energy and environment in its Science and Research Branch in Tehran.

4.1. Universities Offering Energy Programs

The list of universities with active programs in energy is as follows.

- Khajeh Nasir University: M.Eng. in Energy Engineering / Energy Systems
- Sharif University of Technology: M.Eng. & Ph.D. in Energy Engineering /Energy Systems
- Power and Water University of Technology: M.Eng. in Electrical Energy Management
- Materials and Energy Research Center: M.Eng. in Renewable Energy Engineering
- Islamic Azad University, Science and Research branch: M. Eng. in Energy Engineering (Energy Systems, Energy Technology, Renewable Energies), MEng. in Mechanical Engineering (Energy), PhD in Energy Engineering
- Petroleum University of Technology, MEng in different Engineering areas
- University of Tehran: M.A. in Energy Economics
- University of Alameh Tabatabaie: PhD in Economics of Oil and Natural Gas

The university admission is highly competitive and done through the central national examination, partly because demand for higher education is very high in Iran[13]. Prospective students choose their fields and universities based on their scores and ranks in the national exam and the Ministry of Science, Research, and Technology allocates them to the universities based on their ranks and the universities' capacities. Since most of the programs are rather new, their sizes are small. On average, each graduate program in a university takes between 10 to 15 students per year and the program takes two years on average.

4.2. Energy Programs

Most of the energy programs are newly developed and offered at the graduate levels in technical universities in Tehran[14]. Akin to all other education programs in Iran, the energy programs, including curriculum and the terms of the study, are required to be approved by the Ministry of Science, Research, and Technology before they can be offered. The MSc/MEng/MA programs usually consist of 24-26 credit hours courses. In addition, students are required to write a thesis under supervision of an advisor and defend it formally before a committee. The PhD programs also include course work as well as a dissertation and will usually take about 5 years. In the following, we first review the undergraduate programs, and then graduate programs in energy (engineering and economics) offered by the universities in Iran.

4.2.1. Undergraduate Programs

Mechanical Engineering

Islamic Azad University has developed an undergraduate program in energy engineering as part of their mechanical engineering program. Students entering the mechanical engineering program can take certain energy related courses to specialize in energy engineering. The structure of the program is similar to other undergraduate programs consisting of 140 credit hours courses and labs. The general and major courses are the same as courses in mechanical engineering program, but the specialized courses include economic, management, and energy courses. There are in total 46 credit hours of specialized courses as follows.

Principles of economics (1 & 2), operation research, energy strategic planning, energy management, renewable energies, energy modeling in building, transportation, and industry, combustion optimization, central heat and ventilation, mass transfer, energy management in industry, energy conservation in building, energy and environment.

Energy Economics

There is no Energy Economics program at undergraduate level, but there is an Energy Economics course offered as a major or an elective course in Economics Departments. There

[13] The acceptance rate in the national universities is about 15 percent in undergraduate and 10 percent in graduate programs (they are higher if we include distance education and Islamic Azad University). The young population structure and free national universities in Iran are important factors in the demand for higher education.

[14] The exception is the Petroleum University which is in Khusestan, a South-Western province in Iran. The graduates of this university were planned to work in the petroleum industry in southern Iran.

are also courses in natural resources and environment which have some overlaps with energy economics.

4.2.2. Graduate Programs – MEng/MSc/ MA

Energy Economics

Energy Economics is a course offered in undergraduate Economics programs in many universities. There is also a MA program in Energy Economics offered at the Faculty of Economics, University of Tehran. The structure of the program is similar to other MA programs, which consists of 24 credit hours of courses as well as a six credit-hour-equivalent-thesis. The required courses are microeconomics, macroeconomics, econometrics, economics of natural resources, and energy economics. Students can also take three courses from a list of elective courses such as development economics, international trade, international transportation, principles of international financial and commercial laws, and economy of Iran. After finishing courses successfully, students should submit a research proposal and write a thesis under supervision of a faculty. The thesis is evaluated by an advisory committee and a referee and should be defended in an open meeting. The program usually takes two years, but can take between 1.5 to three years.

The MA program in Energy Economics is rather young, but has produced many high quality graduates who have been working in different parts of energy market. It has also laid a good foundation for higher level studies in Energy Economics.

Energy Systems Engineering

Energy Systems Engineering is a MEng program which is offered in three fields: Energy Systems, Energy Technology, and Energy and Environment. The program is interdisciplinary and includes 32 credit hours of courses in engineering, economics, and management including a thesis. The program takes two years and the graduates are expected to work in the areas of energy management and plan, energy production and conversion, research, scientific and technical advice in energy, economic, and environmental organizations. To be eligible to enroll in this program, students must have a degree in engineering, physics, chemistry, or applied mathematics, and write a national entrance exam.

The major courses are energy system analysis, advanced mathematical planning, process engineering, risk analysis, and principles of economics. Students are also required to take additional courses related to their specific fields. For instance, in the field of Energy Technologies, students should take courses in renewable energy technologies such as wind, hydro, biomass, solar, and hydrogen. The Energy Systems program is offered by some technical universities such as Sharif University of Technology, Islamic Azad University, Science and Research branch, and Khaje Nasir University.

Renewable Energy Engineering

Ministry of Science, Research, and Technology approved a MEng program in Renewable Energies in 2006. The objective of the program is to prepare graduates to get involved in teaching and research activities in the areas of renewable energies. The graduates are expected to learn knowledge and skill about principles of different types of renewable energies,

system design, and energy auditing. The structure of the program is similar to other M.Sc programs consisting of 24 credit hours courses and 6 credit hours research project. All first degree graduates in engineering and physics are eligible to take part in the national exam entrance. The required courses are principles of renewable energies (1 and 2), applied math and statistics, energy system design, energy storage and transformation, energy and environment, and energy measurement lab. The list of elective courses students can take includes energy analysis and auditing, solar energy, nuclear energy, wind energy, hydro, biomass and biogas, bio energy, hydrogen, energy resources and uses, management and economics of energy.
The universities that offer a modified version of this program are Islamic Azad University, Science and Research branch, and Sharif University of Technology. The program is part of the main program in Energy Systems.

Energy Engineering
Islamic Azad University has developed its own program in energy engineering. The program is a modified version of the Energy System Engineering developed and approved by the Ministry of Science, Research, and Technology. In this program, Energy Engineering consists of three fields: Energy Systems, Energy Technology, and Renewable Energies. Students take some core courses common in all three fields (30 percent) in addition to courses from their own specific fields.

The courses in Energy Systems are as follows:

> *Required*: Energy system analysis, advanced arithmetic, advanced mathematic programming, process engineering, energy modeling, management and auditing lab.
>
> *Electives*: Advanced math, exergy optimization, pinch technology, optimal control of economic systems, time series analysis and forecasting, energy management in industry, energy and environment.

The courses in Energy Technology are as follows:

> *Required*: Energy system analysis, advanced arithmetic, process engineering, energy conservation in building, advanced heat transformers design, management and auditing lab.
>
> *Electives*: Advance thermodynamics, advanced combustion, advanced fluid mechanics, advanced fuel engines, steam oven designs, energy management in industry, energy and environment.

The courses in Renewable Energy are as follows:

> *Required*: Energy system analysis, advanced arithmetic, advanced mathematic programming, renewable energy 1, renewable energy 2, renewable energy lab., energy transformation and storage technology, wind power plant technology, solar energy systems, and hydrogen technology.

Electives: Direct energy transformation, advanced fluid mechanics, exergy process optimization, advanced hydro power plant, energy and environment, energy conservation in building.

4.2.3. Graduate Programs - PhD

Energy Economics

There is no Energy Economics program at the PhD level, but recently University of Allameh Tabatabaie has started a PhD program in the Economics of Petroleum and Natural Gas. The program includes advanced courses in Microeconomics and Macroeconomics, as well as courses and workshops in oil and natural gas production and markets. Students can specialize in one of the two streams: Oil financial markets, law and contracts in oil markets. The program takes four to six years and consists of courses for two/three years and research for two/three years.

Energy Engineering

In 2005, a new PhD program in Energy Engineering was developed by the Graduate School of Energy and the Environment in Islamic Azad University, Science and Research branch and approved by the university council. The graduates of this program are expected to work in refineries, power plants, industries, transportation, energy system in buildings, and other public and private energy related organizations. The program consists of 24 credit hours course and 24 credit hours equivalent research and takes four to six years. Eligible applicants should have a MEng/MA degree in energy engineering, nuclear energy, mechanical engineering, electrical and power engineering, chemical engineering, industrial engineering, or energy economics. The list of major and elective courses is as follows: energy processing technologies, optimal power transmission system, energy management in industry, optimal control of economic systems, economics of non-renewable energy sources, heat transmitters design, emission control technologies, energy and environment modeling, risk analysis, stochastic process, time series analysis and forecasting, energy pricing, advanced econometrics, advanced microeconomics, advanced macroeconomics, international economics, process engineering, nuclear power plant technology, advanced thermodynamic, exergy process optimization, pinch technology, advanced mathematics, energy conservation in building, steam oven design, power plant design, advanced hydro, advanced combustion engines, advanced combustion, heat transfer, direct energy transformation, process control, and cryogenic.

5. Conclusion

Given the vast resources of energy and high demand for education, the energy education in Iran has been underinvested. Relying on oil revenues and having developed oil and natural gas fields by foreign companies, government did not need to invest on public and university education on energy. However, the harmful impacts of the existing energy policies on energy consumption, energy intensity, environment, and government budget deficit and debt have made it clear that the current policies are not sustainable. Therefore, it is only recently that energy management and energy efficiency concepts are introduced and widely discussed and the prolonged government policy of heavily subsidizing energy is criticized in Iran.

Iran's energy education consists of two areas: Technical education and non-technical education. The former is offered in the engineering faculties and departments and the latter in faculties of economics. Although the energy education programs in higher education institutes, particularly in the area of energy economics and management, started late in Iran, they have been playing an important role in preparing experts and skilled workers for the energy sector. They take in talented students through the national exam competition and graduate them with qualification to work in different sectors of the energy market. However, the energy programs need to develop further particularly in terms of quality and covering new areas such as energy efficiency, renewable energies, and energy policy. The latter is particularly important as the energy markets are becoming more complicated and dynamic, requiring high and multidimensional skills for developing right energy policies for a country. The energy policy programs are interdisciplinary programs consisting of social sciences (economics, political science, sociology, business and management) and engineering (energy systems), which can be offered at the graduate level involving various departments.

With the vast energy resources, Iran needs to catch up with the new concepts, technologies, and management skills developed in the world energy markets through the universities. They can set up joint programs with international universities which have long and high quality reputations in energy programs to exchange professors and students. They can also set up and participate in international workshops and seminars to catch up with new knowledge and the state-of-the-art technologies.

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