Content

1 Background

Each EU Member State is responsible for the organization of its education and training systems and the content of teaching programs. In accordance with Article 165 of the Treaty on the Functioning of the European Union (TFEU), the Union's role is to contribute to the development of quality education by encouraging cooperation between Member States and, if necessary, by supporting and supplementing their action.The EU identifies "New Skills for New Jobs" as an imperative for the future. This project focuses on EIE modules and programs aligned to the 'new' jobs of the future – those in the key global technical challenge areas. The project offers a team of EIE technical expert academics who are very well placed to both propose new curricula, but also be develop models sensitive to new teaching methods and the needs of all learners[1].

"***Europe****: Europe is on track to generate 20% of its energy from renewable sources by 2020. The highest shares of renewable energy consumption in 2010 were in Sweden (47.9%), Latvia (32.6%), Finland (32.2%), Austria (30.1%), and Portugal (24.6%); the lowest were in Malta (0.4%), Luxembourg (2.8%), the United Kingdom (3.2%), and the Netherlands (3.8%). Over 70% of electricity capacity additions in 2011 came from renewable sources in Europe, increasing renewable energy's share of total electricity capacity to 31.1%. Finland's new-generation nuclear plant (European Pressurized Reactor) was planned for completion in 2009 but now is not expected to ready even for the revised 2014 target. Conservation and efficiencies could reduce EU's energy consumption about 30% below 2005 levels by 2050. Low-carbon technologies could provide 60% of energy by 2020 and 100% by 2050, according to the EU's low carbon roadmap. EU plans to have 10–12 carbon capture and storage demonstration plants in operation by 2015. Germany and Switzerland plan to phase out nuclear energy. Poland imports more than 80% of its natural gas from Russia, but its shale gas reserves may provide Poland with enough gas for more than 50 years. Meanwhile, Bulgaria imposed a temporary ban on the exploration and extraction of shale gas in January. Oil extraction in the Arctic offshore territories in Russia might peak at 13.5 million tons a year over the next 20 years in the most optimistic forecasts, compared with 500 million tons produced today. Amsterdam plans to have 10,000 electric cars by 2015. Five geothermal power plants in Iceland meet 27% of the country's electricity needs. Demark plans to have 100% of its energy from renewable sources by 2050. Some Spanish renewable energy experts are leaving after the government cut financial aid to that sector. Shale gas in Central Europe is expected to lower energy prices there within 20 years*."[2]

Engineering faculties struggle to get and keep students engaged in the study of science, whileindustry struggles to attract employees with advanced technical skills. To make the transition to a competitive energy system, we need to overcome a number of challenges, such as increasingly scarce resources, growing energy needs and climate change[3]. In this context we may see a great opportunity to combine the growing international interest in renewable energy with lab science and hands-on skills to provide a truly integrated, contextual curriculum to engage EIE students.

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[1] SALEIE project proposal - online reference: http://www.saleie.co.uk/

[2] "13. How can growing energy demands be met safely and efficiently?"- The Millennium project: online reference: http://www.millennium-project.org/millennium/Global_Challenges/chall-13.html

[3] Secure, Clean and Efficient Energy - Horizon2020- The EU Framework Programme for Research and Innovation: http://ec.europa.eu/programmes/horizon2020/en/h2020-section/secure-clean-and-efficient-energy

1.1 Reference materials

- The HORIZON2020 - Societal Challenges: Secure, Clean and Efficient Energy[4].
- The Millenium Project: 15 Global Challenges[5].
- EIE-Surveyor: EIE defined knowledge, skills and competences[6].
- ELLEIEC: model curricula, organization of study programs (concrete subjects) and subject information letters[7].
- European qualification frameworks and National qualification frameworks[8].
- Introduction to renewable energy technology, M.A. Brown[9].
- NEED: national energy education development project[10].
- Wind energy- Technical University of Denmark[11].
- Study portals (http://www.mastersportal.eu/)[12]

1.2 Focused Global Challenges

13. Energy[13]

1.3 Proposed Model Renewable Energy Curricula - starting points

- **economic aspects**
  - Price of each form (production)
  - Benefits in terms of:
    - Reduced carbon
    - Lower imports (balance of payments)
      - Gas/Oil etc.
    - Local production/Jobs
    - Green energy market
    - Production volumes/balance
  - Legislation/targets
    - Connect with production
    - Connect with technical specifications
- **technical (technology for production) and basic aspects**;
  - Wind: On shore/Off shore
  - Solar

[4] Horizon2020- Societal challenges: http://ec.europa.eu/programmes/horizon2020/en/h2020-section/societal-challenges
[5] http://millennium-project.org/
[6] http://www.eie-surveyor.org/
[7] http://greenelleiec.eu/
[8] http://ec.europa.eu/eqf/home_en.htm
[9] Introduction to renewable energy technology, M.A. Brown, Lakewood high school, online reference: http://www.nrel.gov/education/pdfs/educational_resources/high_school/re_intro.pdf
[10] NEED: national energy education development project; online reference : http://www.wvcommerce.org/news/story/National_Energy_Education_Development_Project_NEED/1301/default.aspx
[11] Wind energy- Technical University of Denmark: online reference: http://www.dtu.dk/english/Education/msc/Programmes/wind_energy#prerequisites
[12] Study portals : http://www.mastersportal.eu/
[13] http://www.millennium-project.org/millennium/Global_Challenges/chall-13.html

        - Water (thermal)
        - PV
            - Generation types: macro (commercial); micro (local use) for individual or community
            - Research (future use of electromagnetic radiation)
    - Hydro
        - Wave
        - Tidal
        - Hydro-electric (reservoir/rivers)
    - Ground source
        - Geothermal (deep/shallow)
    - Heat exchange air source
    - Bio-mass
    - Energy efficiency: advantages and disadvantages

- **smart grid;**
    - Energy management
    - Interconnection renewable energy
    - Embedded energy for transportation and distribution
    - Efficiency of the grid
    - Infrastructure planning: ability to plan efficiently for energy usage
- **working in interdisciplinary teams;**
- **working in international teams (exchange of students);**
    - Education for developing skills
    - Team, language, cultural and communication skills
- **developing innovative skills by open task activities for students;**
- **innovation in energy storage;**
    - Pump storage
    - Fuel cells
    - Supercondensators
- **micro-generation for isolated inhabitation (small farms; villages)**
    - Security energy supply
    - Cost benefits analysis
- **energy management (how to manage better the energy)**
    - Monitoring
    - Reliability
    - Efficiency

2 List of identified modules and programmes, as potential benchmark for our future curricula proposal

2.1 Bachelor study programmes

2.1.1 Study program "Energy Technology"[14] (University College of Northern Denmark, DENMARK, 120 ECTS)

The programme provides knowledge on:
- The energy of the building complex
- Energy supply and conversion
- Energy efficient process and production facilities
- and go on an internship and write a final examination project

Energy Technology is a 2-year AP degree programme divided into 4 semesters each with a disciplinary area in focus.
- **1st semester** The energy of the building complex
- **2nd semester** Energy supply and conversion
- **3rd semester** Energy efficient process and production facilities
- **4th semester** Internship and final examination project

Course	**Semester 1**	**Semester 2**	**Semester 3**	**Semester 4**
Building Technology	10 ECTS			
Thermal engineering, indoor climate systems, automation, control & regulation	3 ECTS	7 ECTS		
Energy Technology, traditional and new forms of energy	5 ECTS			
Energy analyses, energy consumption calculation	5 ECTS			
Planning and energy efficielt projecting		5 ECTS		
Process facilities, data collection and energy technologic automation		2 ECTS	6 ECTS	
Energy-economic and environmental assessment methods			5 ECTS	
Innovation		2 ECTS	2 ECTS	
Business understanding		2 ECTS	2 ECTS	
Project management	2 ECTS	2 ECTS		
Study tools	5 ECTS			
Elective element		10 ECTS	15 ECTS	
Internship				15 ECTS
Final Project				15 ECTS
Total	30 ECTS	30 ECTS	30 ECTS	30 ECTS

Total: 120ECTS[15].

[14] Energy Technology: http://www.ucnorth.dk/Home/Programmes-Courses/Energy_Technology.aspx?utm_source=BachelorsPortal.eu&utm_medium=Premium%20Listing&utm_campaign=Energy%20Technology
[15] Energy Technology - Modules and ECTS; http://www.ucnorth.dk/Home/Programmes-Courses/Energy_Technology/About_the_programme/Modules_and_ECTS.aspx

2.1.2 Study program "Energy Systems Engineering[16]" (Yasar University, Turkey)

240ECTS;
Specific laboratories:

- Control systems laboratory;
- Heat technique laboratory (Thermodynamics, Heat and Mass Transfer, Fluid Mechanics, Heat Exchangers and Measurement Technique);
- Renewable energy laboratory (solar and wind energy)

Details at:
http://international.yasar.edu.tr/programs/

2.1.3 Bachelor Environmental Science for Sustainable Energy and Technology, Avans University of Applied Sciences[17], Netherlands

This programme has a workload of 240 ECTS.
Specialities:

- Environmental Consultancy:
- Biobased Energy:
- Environmental Geography:
  Link: http://www.avans.nl/opleidingen/opleidingzoeker/environmental-science-for-sustainable-energy-and-technology-of-milieukunde-breda-voltijd-bachelor/introductie

2.1.4 B.Sc. Mechanical Engineering in Energy Engineering[18], Karlsruhe Institute of Technology, Germany

The curriculum in Energy Engineering consists of two parts. The intermediate studies in 1st-4th semester and the major studies in 5th and 6th semester.

Intermediate Studies Semester 1 - 4	**Major Studies** Semester 5 - 6
Engineering Mechanics	Fundamentals of Energy Technology
Production Operations Management	Heat and Mass Transfer
Computer Science for Engineers	Technical Combustion
Mechanical Design	Energy Economics
Engineering Thermodynamics	Machines and Processes
Material Science & Engineering	Fluid Mechanics
Advanced Mathematics	Measurement and Control Systems
Wave Phenomena	

[16]http://http//esm.yasar.edu.tr/en/
[17]http://www.avans.nl/opleidingen/opleidingzoeker/environmental-science-for-sustainable-energy-and-technology-of-milieukunde-breda-voltijd-bachelor/introductie
[18]http://carlbenz.idschools.kit.edu/bachelor_energy_engineering.php

Intermediate Studies Semester 1 - 4	Major Studies Semester 5 - 6
Chemistry	
Electrical Engineering & Electronics	

Total ECTS: 180.

Web link: http://carlbenz.idschools.kit.edu/bachelor_energy_engineering.php

2.1.5 Electroenergetic systems & Energy management[19], Faculty of Elecgtrical Engineering of Iasi, Gh. Asachi Technical University of Iasi

4 years, 8 semesters, 240ECTS

1st Semester	2nd Semester
Mathematical analysis Physics Programming I Mechanics Resistance of materials	Differential equations Electromagnetic field theory Computer aided graphics Programming II
3rd Semester	**4th Semester**
Numerical methods in engineering Reliability Fluid mechanics Electro security Electronics	Circuit theory II Electrical machines I Thermotechnics Thermal and hydraulic machines Materials engineering
5th Semester	**6th Semester**
Electrical machines II Electrical measurements Electrical equipments I Electromagnetic compatibility Thermo Equipments I Energy utilization Energy management	Control engineering Transmission and distribution systems I Electrical and Thermo Electricity generation Power engineering Microprocessors
7th Semester	**8th Semester**
Transmission and distribution systems II Electro-energetic systems automation High voltage technique I Electroenergetic systems I Industrial project management	Power plant subsystems High voltage technique II Electroenergetic systems II Optimal strategies in energetics License Project

[19] http://www.ee.tuiasi.ro/academic/plan-de-invatamant/

2.2 Master study programs

2.2.1 M.Sc. L´Ingénieur - EfficacitéÉnergétiqueetÉconomique[20] (University of Luxembourg) - in French

120 ECTS;

Semester 1 (30 ECTS)

Mathématiques (module)
Thermodynamiques (module)
Contrôle de gestion (module)
Droit des affaires (Droit des sociétés) (module)
Computational Fluid Dynamics (module)
Systèmesd'optimisationénergétiques (module)
Énergétique du haut fourneau (module)

Semester 2 (30 ECTS)

Transfert de masse et de chaleur (module)
Policy, assessment and evaluation of energy projects on European level (module)
Efficienceénergétiques des bâtiments (module)
Financial Accounting (module)
Gestiond'entreprise : Analysefinancière (module)
Introduction aux décisionsfinancières de l'entreprise (module)

Semester 3 (30 ECTS)

Thermiqueindustrielle (module)
Combustion industrielle et domestique (module)
Échangeur de chaleur (module)
Intégration des énergiesrenouvelablesdans le bâtiment et l'industrie (module)
Systèmefrigorifiques (module)
Projet II (module)

[20]http://wwwen.uni.lu/formations/fstc/master_professionnel_en_sciences_de_l_ingenieur_efficacite_energetique_et_economique

Simulation de la thermique du bâtiment (module)

Semester 4 (30 ECTS)

Master Thesis (module)

2.2.2 Study programs "Sustainable Energy Engineering[21]" (Iceland school of Energy)

120 ECTS; 18 months.

Programme schedule

	Date	Courses	Credits
Term 1	End of July, 3 weeks	Introductory Field Trip (Opens in new window)	6 ECTS
Term 2	August- December	Mandatory and elective courses	24 ECTS
Term 3	January - May	Mandatory and elective courses	30 ECTS
Term 4/5	June- December	Interdisciplinary project Research project (Opens in new window)	60 ECTS
	18 months		120 ECTS

Courses

Mandatory modules:

Introductory Field Trip (6 ECTS)
Introduction to Earth Sciences (6 ECTS)
Introduction to Energy Technology (6 ECTS)
Introduction to Energy Economics (6 ECTS)
Overview of Sustainable Energy Systems (6 ECTS)
Interdisciplinary Project Course (6 ECTS)

Students must take a minimum of 12 ECTS from the Engineering electives, including one engineering design elective.

Examples of Engineering Electives

- Applied Geophysics (T-866-GEOP)

[21] http://en.ru.is/ise/programmes/engineering/#tab2

Examples of Engineering Electives

- Energy in Industrial Processes (8 ECTS)
- Partial Differential Equations (T-805-HLUT)
- Advance Fluid Mechanics (T-832-AFME)
- Optimisation Methods (8 ECTS)
- Applied Probability (8 ECTS)
- Data Mining and Machine Learning (T812-DATA)
- Stochastic Processes (8 ECTS)
- Simulation (8 ECTS)
- **Linear Dynamical Systems (8 ECTS) (Opens in new window)**
- **Risk Management and Decision Analysis (8 ECTS) (Opens in new window)**
- **Sustainability (8 ECTS) (Opens in new window)**
- **Heat Transfer (8 ECTS) (Opens in new window)**
- Numerical Fluid Mechanics and Heat Transfer
- **Applying Models in Management (8 ECTS) (Opens in new window)**
- **Geographic Information Systems in Transportation and Planning (6 ECTS) (Opens in new window)**
- Data Driven Decision Making
- **Integrated Product Development and Entrepreneurship (8 ECTS) (Opens in new window)**
- **Project Management and Strategic Planning (8 ECTS) (Opens in new window)**
- **Cost Management (6 ECTS) (Opens in new window)**

Curricula available at: http://en.ru.is/ise/programmes/engineering/#tab2

2.2.3 Study program "Environmental and Energy Management[22]" (University of Twente, Netherlands)

Curricula is available at:http://www.utwente.nl/en/education/master/
65 ECTS; one year.

2.2.4 Study program "Wind power systems[23]" (Aalborg University, Denmark)

120ECTS;

1st Semester

This semester is common for the three electrical specialisations in Energy Eengineering: Electrical Power Systems and High Voltage Engineering (EPSH), Power Electronics and Drives (PED) and Wind Power Systems (WPS).The project technical topics are the same, but the students from another university have one extra course which includes theory of **Problem**

[22]http://www.utwente.nl/en/education/master/
[23]http://www.studyguide.aau.dk/programmes/postgraduate/55806/

Based Learning (PBL). This method is the primary teaching method used at Aalborg University.

1st Semester Project for Students with a BSc Degree from Aalborg University: Dynamics in Electrical Energy Engineering

On this semester, focus is on a problem where the dynamics of an electrical energy system or electrical apparatus is to be analysed.

1st Semester INTRO Project for Students with a BSc Degree form Another University than Aalborg University: Problem-based Project-organised Learning in Dynamics in Electrical Energy Engineering

The purpose of this semester is to give the students a comprehension of the Problem Based Learning (PBL) method applied at Aalborg University.

2nd Semester: Interaction between Wind Generation and Load

Students will complete a project in which a wind turbine system has to be controlled under time varying loads, either as a stand-alone system or coupled to a power network. The system is to be modelled, simulated and evaluated with respect to power quality and system stability. It must be determined whether any power compensation units/systems are necessary.

3rd semester: Optimisation, Diagnosis and Control of Electrical Conditions in Wind Turbines and Wind Farms

The project should be based upon a wind turbine system or a wind farm to which an optimisation, control- or diagnostic system is to be set up. First, the system is to be modelled and different system identification methods can be applied to determine the parameters of the system. The system model is verified by simulations and data time series from either a real system or a laboratory set up. Based on the model, the optimisation, control- or diagnostic system is set up to improve the performance of the system, either with regard to power output, energy efficiency, life time extraction, fault detections etc. The system or parts hereof, is to be implemented and verified experimentally.

4th semester: Masters Thesis in Wind Power Systems

The Master's Thesis may study a known problem in the wind power system area. It may be an extension of project work from previous semesters or a completely new topic, possibly in collaboration with the wind industry, energy supply companies or the responsible power system utility.

2.2.5 Study program "Sustainable Energy" (Technical University of Denmark)

120ECTS;

The special MSc program consists of a mandatory first semester including three courses (10 ECTS points each) covering the main aspects of sustainable energy systems:

- Energy Resources, Markets, and Policies
- Modeling and Analysis of Sustainable Energy Systems
- Sustainability-Assessment of Energy Conversion and Use

After first semester on the basis of the bachelor study the student can choose between a number of studying lines within one of these energy subjects:

- Thermal energy
- Biofuels
- Electric energy systems
- Hydrogen and fuel cells
- Energy savings

2.2.6 Study program "Wind energy[24]" (Technical University of Denmark)

Recommended study plans for the five study lines of Wind Energy:

- Mechanics/aerodynamics
- Testing and Measurements
- Mechanics of Materials
- Electrical Wind Turbine Technology
- Electrical Wind Turbine Systems

Curricula is available at:
http://www.dtu.dk/english/Education/msc/Programmes/wind_energy#study_lines

Different other examples can be found on Study Portals website: http://www.mastersportal.eu/

3 Model Curricula for Renewable Energy

3.1 Description

The renewable energy curriculum may have a modular structure aiming to prepare the EIE students to properly respond to the technical challenges in the field.

The main specializations have been identified and enlisted in 1.3 subchapter.

A special interest will be shown to problem based learning.
Remarks:

- First two years of study follow a very similar pattern everywhere (Mathematics, Electronics, Power systems) accounting for fundamental knowledge.
- The focus on renewable energy only seems to happen in the final year or two years for these degree programmes.
- Universities tend to focus on specific types of renewable energies.

3.2 Learning outcomes for EIE in Renewable Energy

Learning outcomes are represented by aims, skills and competences, and knowledge and understanding (EIE- Electrical and Information Engineering; RE- Renewable Energy).

Aims	Skills & Competences	Knowledge & Understanding (K&U)	code
To produce graduates who will enter and contribute to EIE and Renewable energy fields and achieve corporate membership of the Professional Institution.	Ensure fitness for purppose for all aspects of the problem including production, operation, maintenance and disposal	Students must demonstrate their K&U of essential facts, concepts, theories and principles of their engineering discipline and its underpinning science and mathematics.	1
To produce students who can apply their skills to research, design, develop	Investigate and define a problem and identify constraints including environmental and sustainability	Students must understand scientific principles and methodology necessary to underpin their education in their	1

[24] http://www.dtu.dk/english/Education/msc/Programmes/wind_energy#description1

and implement new or existing devices, equipment, systems and practices within EIE & RE	limitations, health & safety and risk assessment issues	engineering discipline, to enable appreciation of its scientific and engineering context and to support their understanding of historical, current and future developments & technologies	
To provide a thorough appreciation of the relationship between theory and practice	Manage the design process and evaluate the outcomes	Students must have an appreciation of the wider multi-disciplinary engineering context and its underlying principles	1
To provide a thorough understanding of the design process and of the need to generate innovative solutions	Understand customer and user needs and the importance of considerations such as aesthetics	Students must understand mathematical principles necessary to underpin their education in their engineering discipline and to enable them to apply mathematical methods, tools and notations proficiently in the analysis and solution of engineering problems	1
To provide experience of a substantial individual project in EIE with a RE component	Identify and manage cost drivers	Students must be able to apply and integrate K&U of other engineering disciplines to support study of their own engineering discipline	1
To develop a high level of proficiency in reporting, communication and team working skills	Use & demonstrate creativity to establish innovative solutions	Students must understand engineering principles and have the ability to apply them to analyze key engineering processes	1
To provide an awareness of the wider commercial management and legal aspects of the EIE & RE industries	Use transferable skills such as Planning, Problem solving and team working as leader/team member where appropriate	Students must be able to identify, classify and describe the performance of systems and components through the use of analytical methods and modelling techniques	1
To ensure that students recognize the need to operate within the code of conduct defined by the relevant professional body	Self learn and improve performance in preparation for CPD activities	Students must be able to apply quantitative methods and computer software relevant to their engineering discipline in order to solve engineering problems	1
To encourage students who wish to broaden their curriculum with optional modules (Y1&2 only) outside of the EIE & RE arena	Effectively use IT facilities and information retrieval skills	Students must be able to understand and apply a systems approach to engineering problems	1
To understand the principles of operation of sustainable energy conversion by wind, wave, tidal, solar, biomass, geothermal and combined heat & power systems including design and operation	Appreciate management techniques used to achieve engineering objectives within that context	Students must appreciate the social, ethical, environmental, economic and commercial considerations affecting the exercise of their engineering judgment	1
To have analyzed the principle aspects of engineering design underpinning the above	Understand the need for engineering activities to promote sustainable development	Students must be able to demonstrate creative and innovative abilty in the synthesis of solutions and in formulating designs to comprehend	1

technologies and be able To perform preliminary technology assessments		the broader picture and apply an appropriate level of detail	
To have a reasoned appreciation of the constraints on each technology, both imposed by physical fundamentals and by current levels of technology and market dynamics & economics - supported by quantitative evidence where possible	Communicate effectively through a variety of media including oral, visual, diagrammatic, written and on-line	Students must have an awareness of the framework of relevant legal requirements governing engineering activities including personnel, health & safety and risk issues (including environmental risk)	1
To understand the fundamentals of grid connection of distributed generators and the associated problems and constraints	Effectively manage time and resources and to use workshop and laboratory skills	Students must understand the need for a high level of professional and ethical conduct in engineering	1
To conduct independent literature searches on sustainable energy technologies including academic, government, agency and news media sources; be practiced in critically appraising the quality of the source and synthesizing from them	Show knowledge of characteristics of particular materials, equipment, processes or products	Students must show a comprehensive K&U of mathematical and computer models relevant to the engineering discipline and have an appreciation of their limitations	1
To develop preliminary exploitation plans and calculations to quantify energy flows for defined regions considering the resource, technology and environmental issues or social limitations	Understand contexts in which engineering knowledge can be applied (e.g. Ops, Mgmt, Development etc)	Students must be able to report on an extended project either individually or as a group member meeting deadlines and presenting written and graphical material in a properly structured and literate way	1
To complete a simple dimensioning and design project for an appropriate RE technology exploring the full extent of that technologies capabilities and variants	Apply appropriate codes of practice and industry standards	Students must be able to discuss the realities, intricacies and complexity of sustainable energy issues to critically appraise and to detect and reject over-simplified assertions and/or solutions	1
To provide an awareness of environmental, economic, social, political and ethical drivers for sustainable energy globally	Understand IP and contractual issues		1
To provide leading edge specialist skills and in depth knowledge of key	Use technical literature and other info sources		1

selected areas in EIE and RE.			
To describe strategies for developing sustainable energy sources and for reducing energy demand on both locally and globally	Consider quality issues		1
To summarize the current world-wide pattern of energy production and use, the corresponding environmental impact and the future trends	Work with technical uncertainty		1
To recognize the basis of operation and carry out heat transfer performance analysis for modern energy systems.	Define roles and responsibilities for implementation of EMS	be conversant with the regulatory requirements for statutory EIA;	2
To discuss population, urban, and economic growth strategies and their impacts	Provide structure for management procedures to control environmental impacts	be familiar with some of the methodologies commonly used in preparing EIA, including public participation	2
To have the ability to understand different stakeholder perspectives to businesses and sustainable development	Demonstrate processes for review of environmental performance.	learn how to evaluate the quality of an Environmental Impact Statements using the criteria used in the UK by the Institute of Environmental Management and Assessment (IEMA).	2
To be able to formulate an appropriate structure to enable an organization to control its environmental performance	Review company reports and publications	Sound knowledge and skills portfolio on EIA that can be offered and utilized in environmental and engineering consultancies, local government and environmental regulators.	2
To have the ability to evaluate an organization's performance against agreed criteria	Identify extent of compliance with ISO 26000 Guidance.	Engineering Analysis Understanding that the consideration of environmental impacts early in the development of engineering projects will allow for identification of suitable (and unsuitable) locations for a better development and a better assessment of options.	2
		Environmental context: Class focuses on EIA and therefore covers all these aspects: biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage including architectural and archaeological heritage and landscape.	2

The rows coded with 1 accounts for the learning outcomes that are expected also at University of Edinburg, UK(Bachelor and Master courses in "Electrical Engineering with Renewable

Energy"[25]; Master in " Engineering for Sustainable Energy"[26]). Additionally, on rows coded with 2, the University of Strathclyde[27], UK (Master in Sustainable Engineering; Master in Renewable Energy Systems and the Environment) enlist few more learning outcomes. The above table represents a strong database with the envisaged aims, skills and competencies, knowledge and understanding in Renewable Energy. University of Exeter[28], UKproposesome more aims than the above enlisted in the table like:

- To design, manufacture assemble and install a borehole sized self-rectifying turbine
- To consider Carbon and the energy balance for Uranium mining
- To be able to apply thermographic imaging to identify heat loss from buildings
- To carry out performance monitoring on domestic scale wind turbines
- To test the performance of turbojet engines using other fuel types
- To explore energy storage technologies

<u>Topics of interest for EIE in Renewable Energy</u>

Energy management
Photovoltaics
Heat storage
Liquid biofuels
Hydropower
Wind energy
Turbines
Smart grids
Geothermal energy
Hydrogen production
Heat transport and supply, district heating
Storage of electricity, batteries
Transmission of electricity
Transport and storage of gas and liquid fuels
Transport and storage of hydrogen
Power to gas technology
Fuel cell, hydrogen production
Fuel liquefaction, gasification
Furnace technology, construction of heating boilers
Generators, electric engines and power converters
Heat exchangers
Heat pump, cooling technologies
Heating, ventilation
Turbines, fluid machinery, reciprocating engines, combined heat and power
Combined heat and power CHP engines
Other energy related machinery
Micro-generation and grid connection
Heat pump

[25] http://www.ed.ac.uk/studying/undergraduate/degrees?action=programme&code=H6H2&cw_xml=index.php
[26] http://www.ed.ac.uk/studying/undergraduate/degrees?action=programme&code=H225&cw_xml=index.php
[27] http://www.strath.ac.uk/
[28] http://www.exeter.ac.uk/undergraduate/degrees/engineering/

Furnace and boiler technologies
Compression and liquefaction of gases
Cooling technologies
Fuel cells
Coal and Hydrocarbons
Gaseous fossil fuel
Solid fossil fuel
Liquid fossil fuel
Mining and extraction
Nuclear Fission/Nuclear Fusion
Gaseous biomass
Liquid biomass
Solar/Thermal energy
Solid biomass
Unconventional and Alternative Energies
Waste incineration
Waste to energy other
Energy from wastewater
Bio-refineries for energy
Integrated waste-energy processes
Lighting, illumination
Process optimisation, waste heat utilisation
Thermal insulation, energy efficiency in buildings
Low, zero and plus energy rating
Thermal insulation
Heat pipes
Combustion, Flames
Fuel Technology
Fuels and engine technologies
Micro- and Nanotechnology related to energy

3.3 Proposed curricula for Renewable Energy

A preliminary form for the curricula might be:

Bachelor: 180 ECTS

1st Semester	**2nd Semester**
Mathematical analysis I Linear Algebra Physics Programming Computer calculations and simulation programs	Mathematical analysis II Electromagnetism Circuit analysis I Foundations of business administration Environmental engineering

3rd Semester	4th Semester
Statistics and computational methods Thermodynamics for energy systems Mechanical engineering for energy systems Circuit analysis II Electronics	Electrical machines I Resistance of materials Automated systems Materials engineering Microcontrollers & DSP
5th Semester	**6th Semester**
Fabrication technologies Power electronics Electrical machines II Control engineering Foundations on renewable energy (wind, solar, biomass, hydro…) Choice of 5 courses	Transmission and distribution systems Electricity generation with renewable energy Energy management Project management office Choice of 2 courses Degree project (20 ECTS)

Master: 120 ECTS

1st Semester	2nd Semester
Electrical power systems Wind energy Solar energy Biomassenergy Hydroenergy Future energy sources	Analysis and simulation of electrical systems Smart grid Energy storage Energy management with renewable energy Distributed generation and micro-grids Measurement and testing laboratory
3rd Semester	**4th Semester**
Energy efficiency and power quality Alternative combustion for thermal generation Analysis and control of variable speed generators Optimization and heuristics Integration of renewable energy Safety of electrical installations and equipment	Creativity, innovation and leadership Interdisciplinary and international teams Energy markets Renewable energy benefits and legislation Master project

During the workshops held in Cesme, Izmir, Turkey, 28-29 May, EAEEIE Conference 2014[29] and York, UK, 9-10 September, ITHET2014[30], the curriculum has been discussed and improved. The results have been published also at EPE2014 Conference[31], Iasi, Romania, 16-18 October, 2014. The final form is presented below:

Renewable Energy curriculum: Bachelor - 180ECTS - 6 SEMESTERS

Semester 1 -4: *120ECTS*

Compulsory modules contents:

- **Mathematics** (fundamental)
- **Programme applied mathematics with projects**
- **Programme Applied Physics**
- **Computer Science** (basic programming, mathematical programming, databases, networking, operating systems)
- **Circuit theory (DC, AC, 3-phase systems)**
- **Basic Analogue and Digital Electronics with projects**
- **Basic of control engineering**
- **Fundamentals of power systems**
- **Applied electromagnetics & Electrical machines**
- **Basic of entrepreneurship, project management**
- **Communication and Engineering Methodology** (soft skills, written and oral presentation, ethics)
- **Technological Awareness** (e.g. short seminars with industry experts): optional
- **English language (basics, technical):** country specific

5th Semester: 3 compulsory+2 optional- 30 ECTS

Power electronics

RE1B: Foundations on renewable energy (wind, solar, biomass, hydro…)

RE2B: Transmission and distribution systems

Control engineering II : **optional**

RE3B: Fabrication technologies: optional

RE4B: Protections in power systems: optional

6th Semester - 30 ECTS

Internship and/or **Bachelor project**

[29] Poboroniuc M. S., Livint G., Friesel A., Cojocaru D., Popescu D., Grindei L., Naaji A., Ward A., ***Trends and EIE higher education response to the current global technical challenges***, in Proceedings of the 25th International Conference on European Association for Education in Electrical and Information Engineering, EAEEIE 2014, Izmir, Turkey, 30 May-1st June 2014, Article number 6879388, Pages 65-68, Category numberCFP1496D-ART; Code 107220, DOI: 10.1109/EAEEIE.2014.6879388, **indexed Scopus & IEEE *Xplore.***

[30] Marian Poboroniuc, Gheorghe Livint, Noel Jackson, Dorian Cojocaru, Dorin Popescu, Laura Grindei, Antoanela Naaji and Anthony Ward, ***A survey results on existing electrical and information engineering programmes oriented to key global technical challenge areas***, in Proceedings of the ITHET2014 Conference, 11-13 September 2014, York, UK, 8pg.

[31] Marian Poboroniuc, Gheorghe Livint, Juan José Marcuello Pablo, Anna Friesel, Laura Grindei and Anthony Ward, ***SALEIE: An EU project aiming to propose new eie curricula oriented to key global technical challenges***, in Proceedings of the EPE2014 Conference, 6pg., Iasi, Romania, 2014.

Renewable Energy curriculum: Master - 120ECTS - 4 SEMESTERS

1st Semester:

Compulsory modules:

RE5M1	Renewable energies
RE6M1	Optimization &Prevision methods
RE7M1	Analysis and simulation of electrical systems

RE8M1	Wind Energy Generation and Transmission
RE9M1	Biomass energy

2nd Semester:

Compulsory modules:

RE10M2	Energy management with renewable energy
RE11M2	Smart grids
RE12M2	Power converters

RE13M2	Photovoltaic Energy Course
RE14M2	Geothermic Energy Course

3rd Semester:

Compulsory modules:

RE15M3	Integration of renewable energy
RE16M3	Energy markets
RE17M3	Green Energy Planning

Optional modules:

RE18M3	Energy Storage
RE19M3	Hydro Power Generation, Storage and Transmission
RE20M3	Fuel Cells energy

4th Semester **Master project**

In order to describe each module (mostly those which embed the global challenges seeds) a template has been discussed and proposed:

Template

University/Department:

Module name:

Programme (Energy/ICT):

ECTS:

Type Bachelor/Msc :

Module name:

Scope and form:

Duration (weeks; Hours/week):

Type of assessment:

Qualified Prerequisites:

General course objectives:

Topics and short description:

Learning outcomes:

Knowledge	Skills	Competences

Module recommended literature:

Remarks:

Definitions:

• **Curriculum:** The aggregate of courses of study given in a learning environment. The courses are arranged in a sequence.

• **Syllabus:** Is an outline and summary of topics to be covered in an education or training course.

• **Programme (or courses):** A plan of modules to be covered to achieve a specific degree and/or qualification.

• **Module:** Lectures, labs and other activities related to one subject.