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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 <u>development of quality education by encouraging cooperation between Member States</u> and, if necessary, by supporting and supplementing their action. The EU identifies "<u>New Skills for</u> <u>New Jobs</u>" 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 <u>new curricula</u>, but also be develop models sensitive to new teaching methods and the needs of all learners¹.

"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 newgeneration 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 change³. 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.

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

- <u>The HORIZON2020</u> Societal Challenges: Secure, Clean and Efficient Energy⁴.
- <u>The Millenium Project:</u> 15 Global Challenges⁵.
- <u>EIE-Surveyor</u>: EIE defined knowledge, skills and competences⁶.
- <u>ELLEIEC</u>: model curricula, organization of study programs (concrete subjects) and subject information letters⁷.
- <u>European qualification frameworks</u> and National qualification frameworks⁸.
- Introduction to renewable energy technology, M.A. Brown⁹.
- NEED: national energy education development project¹⁰.
- Wind energy- Technical University of Denmark¹¹.
- Study portals (<u>http://www.mastersportal.eu/</u>)¹²

1.2 Focused Global Challenges

13. <u>Energy</u>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

⁵http://millennium-project.org/

⁶http://www.eie-surveyor.org/

⁷http://greenelleiec.eu/

⁸http://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/defau lt.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/

¹³http://www.millennium-project.org/millennium/Global_Challenges/chall-13.html

- Water (thermal)
- o PV
 - Generation types: macro (commercial); micro (local use) for individual or community
 - Research (future use of electromagnetic radiation)
- Hydro
 - o Wave
 - o Tidal
 - o Hydro-electric (reservoir/rivers)
- Ground source
 - Geothermal (deep/shallow)
- Heat exchange air source
- Bio-mass
- Energy efficiency: advantages and disadvantages
- <u>smart grid;</u>
 - 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: 120ECTS¹⁵.

¹⁴ Energy Technology: http://www.ucnorth.dk/Home/Programmes-

Courses/Energy_Technology.aspx?utm_source=BachelorsPortal.eu&utm_medium=Premium%20Listing&utm_c ampaign=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 Engineering¹⁶" (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 Sciences¹⁷, Netherlands

This programme has a workload of 240 ECTS. Specialities:

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

2.1.4 B.Sc. Mechanical Engineering in Energy Engineering¹⁸, 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	

¹⁶http://http//esm.yasar.edu.tr/en/

¹⁷http://www.avans.nl/opleidingen/opleidingzoeker/environmental-science-for-sustainable-energy-and-

technology-of-milieukunde-breda-voltijd-bachelor/introductie

¹⁸http://carlbenz.idschools.kit.edu/bachelor_energy_engineering.php

Intermediate Studies	Major Studies
Semester 1 - 4	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 management¹⁹, Faculty of Elecgtrical Engineering of Iasi, Gh. Asachi Technical University of Iasi

4 years, 8 semesters, 240ECTS

1 st Semester	2 nd Semester
Mathematical analysis Physics Programming I Mechanics Resistance of materials	Differential equations Electromagnetic field theory Computer aided graphics Programming II
3 rd Semester	4 th Semester
Numerical methods in engineering Reliability Fluid mechanics Electro security Electronics	Circuit theory II Electrical machines I Thermotechnics Thermal and hydraulic machines Materials engineering
5 th Semester	6 th 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
7 th Semester	8 th Semester
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

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

2.2 Master study programs

2.2.1 M.Sc. L'Ingénieur - EfficacitéÉnergétiqueetÉconomique²⁰ (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)

²⁰http://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 Engineering²¹" (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 <u>Research project</u> (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)

²¹http://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)
- <u>Risk Management and Decision Analysis (8 ECTS) (Opens in new window)</u>
- <u>Sustainability (8 ECTS) (Opens in new window)</u>
- Heat Transfer (8 ECTS) (Opens in new window)
- Numerical Fluid Mechanics and Heat Transfer
- Applying Models in Management (8 ECTS) (Opens in new window)
- <u>Geographic Information Systems in Transportation and Planning (6</u> ECTS) (Opens in new window)
- Data Driven Decision Making
- <u>Integrated Product Development and Entrepreneurship (8 ECTS) (Opens in new</u> <u>window)</u>
- 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 Management²²" (University of Twente, Netherlands)

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

2.2.4 Study program "Wind power systems²³" (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**

²²http://www.utwente.nl/en/education/master/

²³http://www.studyguide.aau.dk/programmes/postgraduate/55806/

<u>Based Learning (PBL)</u>. 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 energy²⁴" (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	code
		(K&U)	
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 purpopse 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	Investigate and define a problem	Students must understand scientific	1
can apply their skills to	and identify constraints including	principles and methodology necessary	
research, design, develop	environmental and sustainability	to underpin their education in their	

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

existing devices, equipment, systems and practices within EIE & RE appreciation of its scientific and engineering context and to support their understanding of historical, current and future developments & technologies To provide a thorough understanding of the design process and of the read to generate innovative solutions To provide a thorough understanding of the design process and of the needs and the importance of considerations such as aesthetics onsiderations such as aesthetics innovative solutions To provide experience of a substantial individual projectin EIE with a RE communication and team working skills To provide a harpenet innovative solutions To develop a high level of proficiency in reporting. To provide a mavenenes to establish innovative solutions To provide a mavenenes of the wider commencial proficiency in reporting. Planning. Problem solving and team working skills To ensure that students recognize the need to generate innovative solutions To develop a high level of proficiency in reporting. Planning. Problem solving and team working skills such as Scudents must be able to identify, the relevant professional proficiency in reporting. Planning. Problem solving and team working skills such as Scudents must be able to identify, the relevant professional solutions to concurre that students recognize the need to performance in preparation for coperate within the code of operate within the code of operation the relevant professional solutions the relevant professional solutions the relevant professional solutions proficient of the site apply the relevant professional solutions proficient of the Els & RE information retrieval skills the relevant professional solution to appreciate the social, engineering problems solving and mapta systems approach to engineering problems probl	and implement new or	limitations, health & safety and	engineering discipline, to enable	
equipment, systems and practices within EIE & REManage the design process and evaluate the outcomesengineering context and to support their understanding of historical, current and future developments & technologies1To provide a thorough enedto appreciation of the relationship between theory and practiceManage the design process and evaluate the outcomesStudents must have an appreciation of the wider multi-disciplinary engineering context and its underlying principles1To provide a thorough understanding of the design process and of the reads and the importance of a substantial individual proficiplesUnderstand customer and user needs and the importance of considerations such as aesthetics tools and notations proficiently in the analysis and solution of engineering disciplines to tools and notations proficiently in the analysis and solution of engineering disciplines to support study of their own engineering principles and have the ability to apply them to analyze key engineering principles and have the ability to apply them to analyze key engineering processand1To provide an awareness recommercial management and legal team working skillsUse transferable skills such as proficement processand team working skillsStudents must be able to denutify, engineering processand1To encourage students why with the torded their curriculum with optional modues (Y182 only outside the engineering discipline and team working as leader/ream professional body1To encourage students why with the corded their curriculum with optional modues (Y182 only outside the engineering able to demonstrate engineering problems1To	existing devices,	risk assessment issues	appreciation of its scientific and	
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engineering design underpinning the abovesustainable developmentsynthesis of solutions and in formulating designs to comprehend	principle aspects of	engineering activities to promote	creative and innovative abilty in the	
underpinning the above formulating designs to comprehend	engineering design	sustainable development	synthesis of solutions and in	
	underpinning the above		formulating designs to comprehend	

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 BE			
To describe strategies for	Consider quality issues		1
developing sustainable			-
energy sources and for			
roducing operav domand			
on both locally and			
To summarize the	Mark with tachnical uncortainty		1
current world wide	work with technical uncertainty		1
current wond-wide			
production and use the			
corresponding			
corresponding onvironmental impact			
and the future trends			
To recognize the basis of	Define relac and responsibilities	be conversant with the regulatory	2
operation and carry out	for implementation of EMS	requirements for statutory EIA:	2
boot transfor	for implementation of Elvis	requirements for statutory EIA,	
nerformance analysis for			
modern energy systems			
To discuss nonulation	Provide structure for	he familiar with some of the	2
urban and economic	management procedures to	methodologies commonly used in	-
growth strategies and	control environmental impacts	preparing FIA including public	
their impacts	control environmental impacts	narticination	
To have the ability to	Demonstrate processes for	learn how to evaluate the quality of	2
understand different	review of environmental	an Environmental Impact Statements	
stakeholder perspectives	nerformance	using the criteria used in the LIK by	
to businesses and	performance.	the Institute of Environmental	
sustainable development		Management and Assessment (IFMA)	
To be able to formulate	Review company reports and	Sound knowledge and skills portfolio	2
an appropriate structure	publications	on FIA that can be offered and utilized	
to enable an organization		in environmental and engineering	
to control its		consultancies. local government and	
environmental		environmental regulators.	
performance			
To have the ability to	Identify extent of compliance	Engineering Analysis Understanding	2
evaluate an	with ISO 26000 Guidance.	that the consideration of	
organization's		environmental impacts early in the	
performance against		development of engineering projects	
agreed criteria		will allow for identification of suitable	
		(and unsuitable) locations for a better	
		development and a better assessment	
		of options.	
		Environmental context: Class focuses	2
		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	1

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 Strathclyde²⁷, 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 Exeter²⁸, UK proposesome 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

Topics of interest for EIE in Renewable Energy

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

²⁶http://www.ed.ac.uk/studying/undergraduate/degrees?action=programme&code=H225&cw_xml=index.php ²⁷http://www.strath.ac.uk/

²⁵http://www.ed.ac.uk/studying/undergraduate/degrees?action=programme&code=H6H2&cw_xml=index.php

²⁸http://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**

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

3 rd Semester	4 th 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
5 th Semester	6 th 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	

1 st Semester	2 nd 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
3 rd Semester	4 th 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 2014²⁹ and York, UK, 9-10 September, ITHET2014³⁰, the curriculum has been discussed and improved. The results have been published also at EPE2014 Conference³¹, 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 : <u>optional</u>

RE3B: Fabrication technologies: optional

RE4B: Protections in power systems: <u>optional</u>

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

	Wind Energy Generation and	
RE8M1	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:

• <u>Curriculum</u>: 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.