RESEARCH REPORTS IN BIOLOGICAL AND
ENVIRONMENTAL SCIENCES 92

David Agar, Margareta Wihersaari,
Miia Jämsén, Heli Ratia ja Jenni Päällysaho

International Bioenergy Education in Europe – An Overview

UNIVERSITY OF JYVÄSKYLÄ, 2011

Jyväskylän yliopiston bio- ja ympäristötieteiden laitoksen tiedonantoja 92
Research reports in biological and environmental sciences 92

David Agar, Margareta Wihersaari, Miia Jämsén, Heli Lassila ja Jenni Päällysaho

INTERNATIONAL BIOENERGY EDUCATION IN EUROPE – AN OVERVIEW

Projekti nro S10912

Keskisuomalaisen bioenergiaklusterin osaavan työvoiman turvaaminen

– BEV-osaaja

Leverage from the EU 2007–2013

Centre for Economic Development, Transport and the Environment

LÄNSI-SUOMEN LÄÄNINHALLITUS

UNIVERSITY OF JYVÄSKYLÄ

European Union
European Social Fund

University of Jyväskylä, 2011

Toimittaja:

Timo Ålander (timo.j.a.alander@jyu.fi)

Kansikuva: Koivun vesiverso, kuvaaja Noora Nuutinen

ISBN 978-951-39-4222-9 (nid.)
ISBN 978-951-39-4223-6 (verkkoj.)

Jyväskylän yliopistopaino, 2011

TOIMEKSIANTO

Jyväskylän ammattikorkeakoulu, Jyväskylän yliopisto sekä Pohjoisen Keski-Suomen oppimiskeskus käynnistivät vuonna 2009 yhteisen kehittämishankkeen bioenergia-alan osaavan työvoiman turvaamiseksi Keski-Suomessa. Hanke koostuu kahdesta osakokonaisuudesta: ympärivuotinen työllisyys ja kestävän bioenergiatulevaisuuden rakentaminen. Jyväskylän ammattikorkeakoulu ja Pohjoisen Keski-Suomen Oppimiskeskus ovat vastuussa ensimmäisen ja Jyväskylän yliopisto jälkimmäisen osakokonaisuuden toteutumisesta.

Tämä raportti on osa Jyväskylän yliopiston koordinoimaa osakokonaisuutta 'Kestävän bioenergiatulevaisuuden rakentaminen', joka on toteutettu yhteistyössä Jyväskylän ammattikorkeakoulun ja Pohjoisen Keski-Suomen oppimiskeskuksen kanssa. Osakokonaisuuden päätavoitteena on rakentaa bioenergia-alalle elinikäisen oppimisen polku tunnistamalla alan ammattien osaamis- ja koulutustarpeet ja parantamalla näiden oppimispolkujen toimivuutta Keski-Suomen alueella. Kestävän bioenergiatulevaisuuden rakentamista varten etsitään ratkaisuja työvoimareservissä ja työelämässä olevien osaamisen kehittämiseen. Tunnistettujen oppimispolkujen resursseja pyritään vahvistamaan lisäämällä seudullisten koulutusorganisaatioiden verkostoitumista ja yhteistyötä. Pyritään suunnittelemaan ja demonstroimaan uusia toimenpideratkaisuja ja verkostoja, jotta koulutusorganisaatioiden nykyistä henkilökuntaa, osaamista sekä opetustarjontaa hyödynnetään maksimaalisesti bioenergiatulevaisuuden rakentamisessa sekä koulutustuotteiden kehittämisessä.

Osakokonaisuuden tuloksena tavoitellaan kestävää bioenergiakoulutuksen tulevaisuutta, jossa

- on tehokas elinikäisen oppimisen polku,
- on riittävästi tietoa tarjolla bioenergia-alan ammateista ja koulutusmahdollisuuksista,
- koulutuksen päivittäminen työmarkkinoiden kysynnän mukaan on joustavaa,
- koulutusorganisaatiot tekevät saumattomasti yhteistyötä,
- oppiminen tapahtuu laajasti mm. eri ikä-, työtehtävä- ja koulutustasoilla.

Lisäksi hankkeessa tavoitellaan keskisuomalaisen bioenergiaosaamisen näkyvyyden kasvua tieteellisissä foorumeissa.

'Kestävän bioenergiatulevaisuuden rakentaminen'-osakokonaisuuden vastuuhenkilönä on toiminut TkT Margareta Wihersaari Jyväskylän yliopiston bio- ja ympäristötieteiden laitokselta. Keskisuomalaisen bioenergiaklusterin osaavan työvoiman turvaaminen – BEV-osaaja-hanke on saanut pääosan rahoituksesta Euroopan sosiaalirahaston (ESR) sekä valtion rahoituksen kautta. Rahoitus on yli 495 000 euroa. Hanke päättyy vuonna 2012.

SAATESANAT

Englanninkielinen bioenergian maisterikoulutus on jo arkipäivää Keski-Suomessa. Hyvistä opiskelijoista kilpaillaan sekä kansallisella että kansainvälisellä tasolla. Kansainvälinen bioenergiakoulutuksen tarjonta on kiinnostavaa myös seudullisesti ja sitä on peilattava Keski-Suomen kansainväliseen maisterikoulutukseen. Meidän on osattava vastata mm. seuraaviin kysymyksiin: Tarjoaako Keski-Suomen bioenergiakoulutus jotakin mitä muualla ei vielä ole? Miltä osin meidän koulutus on parempi kuin muiden? Mihin asiaan mahdollinen kilpailuetumme perustuisi? Mitä koulutuksessa pitäisi kehittää edelleen ja mitä ei kannattaisi kehittää Keski-Suomessa? Voisimmeko muuttaa koulutustarjontaamme muuttaa rahaksi? Olisiko koulutuksia mainostettava voimakkaammin? Mistä löytyvät Keski-Suomen vahvimmat kilpailijat ja potentiaaliset yhteistyötahot – kotimaasta (kuten Lappeenrannasta) vai jostakin muualta (kuten Belgiasta – EUREC)? Keskitymmekö valitsemaan opiskelijoita pelkästään tietyistä maista vai maailmanlaajuisesti? Varaammeko koulutuspaikkoja suomalaisille opiskelijoille? On siis erittäin tärkeä pohtia englanninkielisen maisterikoulutuksen tarkoitusta Keski-Suomessa – miksi haluamme (vai haluammeko?) ylläpitää kansainvälistä bioenergiakoulutusta? Tavoittelemmeko muutakin kuin kansainvälistymistä yleisellä tasolla?

Yleisesti ajatellaan, että ulkomaalaiset opiskelijat tutustuvat isäntämaan tutkimus- ja yritystoimintaan ja ovat siten potentiaalisia, kansainvälisiä yhteistyötahoja palattuaan kotimaahansa. Ulkomaalaiset opiskelutoverit tuovat myös suomalaisille opiskelijoille mahdollisuuden oppia tuntemaan bioenergiaan liittyviä erilaisia tuotanto- ja käyttöolosuhteita kotimaan ulkopuolelta. Opintojen kansainvälisyys auttaa myös ymmärtämään paremmin kulttuurieroja. Opiskelutoverit todennäköisesti ystävystyvät synnyttäen, myös ammatillisesti pysyviä, kansainvälisiä kontakteja. Onko Keski-Suomen bioenergiakoulutus sellainen, että edellä mainitut asiat on huomioitu ja niitä myös hyödynnetään?

Tämä selvitys on vasta pintaraapaisu aiheesta ”kansainvälinen maisteritasoinen bioenergiakoulutus”, mutta antaa silti ensimmäisiä vastauksia edellä nouseviin kysymyksiin. Selvityksessä on käyty läpi kaikki Euroopassa tarjotut englanninkieliset uusiutuvan energian, erityisesti bioenergiaan painottuvat, maisterikoulutukset Internetin kautta saatujen tietojen perusteella. Pääosa tiedonhankinnasta on tehty marras-joulukuussa 2009 ja tiedot on täydennetty keväällä 2010.

Uusiutuvaan energiaan liittyvää kansainvälistä maisteritasoista koulutusta on jo tarjolla monessa Euroopan maassa. Koulutus on useimmiten liitetty joko teknilliseen tai luonnontieteelliseen tiedekuntaan. Selvityksen tekijöille on ollut yllätys, ettei englanninkielistä maisteritason bioenergiakoulutusta juuri ole Euroopassa. Yksittäisiä moduuleja on tarjonnassa, mutta kokonaisuuksia, joista olisi mahdollista ponnistaa kovan luokan bioenergia-asiantuntijaksi tai jopa tohtoriksi ei oikeastaan löytynyt. Lukija päättäköön itse, onko tällaista tarjontaa vielä lainkaan Euroopan alueella!

Selvityksen pohjalta voidaan suositella jatko-toimenpiteeksi perusteellisempaa ja internetin tietotasoa syvempää tutkimusta. Erityisesti lisäselvitystä vaativat tiettyjen koulutusohjelmien opiskelijamäärät ja kansallisuudet, koulutusohjelmien maksullisuus, opiskelijoiden tutkielma-aiheet ja heidän sijoittuminen työelämään, maisteriohjelmiin liittyvä tutkimustoiminta, koulutusohjelmien avainopettajat ja heidän halukkuutensa osallistua kansainväliseen vaihto-toimintaan, ohjelmien nykyiset vaihto-opiskelija-aktiviteetit sekä tohtorikoulutus. Potentiaalisiin yhteistyöyliopistoihin tutustuminen paikallisesti on jatkotutkimuksen kannalta suositeltavaa ja kannattavaa. Selvitys on rajattu Eurooppaan, mutta olisi hyvä tehdä samanlainen kartoitus mm. USA:n ja Kanadan koulutustarjonnasta.

Jyväskylä, 8. Helmikuuta 2011

Margareta Wihersaari

CONTENT

1 Introduction

In order to reach set goals in its own renewable energy policy, and mitigate its carbon dioxide emissions, Europe will see significant increases of biomass in energy generation in the years ahead. As a key example of biomass utilisation, Finland itself has set ambitious targets for increased production which will require a skilful labour force in the future. A three-year project (2008-2011) has been launched by the JAMK University of Applied Sciences (JAMK), the University of Jyväskylä (JYU) and the Vocational Education Institute of Northern Central Finland (POKE) in order to ensure the sufficiency of a skilled labour force in the bioenergy sector in Central Finland. Education at all levels is the foundation for development of any labour force and part of the project objectives are to assess the availability of learning and the needs of Masters-level education in renewable energy as it relates to bioenergy production.

The accessibility of university-level educational programmes to foreign students has improved in recent years due to the Bologna Process. The Bologna Process (or Bologna Accords) aims to create a European Higher Education Area by making academic degree standards and quality assurance standards more comparable and compatible throughout Europe. Currently, there are 47 participating countries in the Bologna Process [1]. The goal of creating a European-wide educational area is to make it possible for students and academics to use their qualifications in another education system or country without losing the full value of those qualifications. International Masters programmes with English as the language of instruction have been introduced to many universities to stimulate student mobility and international networking. In order to be successful in recruiting foreign students, educational curriculum (among other factors) must be relevant to the needs of the students and be of high quality.

The main aim of this review is to document Masters level programmes existing in Europe for studies in the field of renewable energy with a focus on bioenergy (solid fuels, production chains and conversion technologies). With this in mind, an answer to the following question is sought: Is Central Finland offering a unique education and/or expertise in the field of bioenergy or can similar programmes be found in other places within Europe? The findings aim to identify institutions which may be competitors of educational providers in Central Finland and/or be good candidates for educational cooperation. For example, an institution may offer complementary expertise in an area of education which is underdeveloped or lacking in Central Finland. Such institutions may be suitable candidates for the join integration of Masters level programmes through which student exchanges could provide for a valuable means of top-level training of students. Teacher exchange for shorter or longer periods as well as cooperation in the field of producing education material, e-learning material etc could also be permitted together with key universities.

2 Scope

Europe has a vast network of post-secondary educational facilities. With this in mind, the scope of this review considers only Masters-level educational providers which offer a programme whose language of instruction is English. The countries considered are the current 27 countries in the European Union along with Switzerland, Norway and Iceland. It is worth noting that the Nordic countries (Sweden, Denmark, Norway and Iceland) are given special emphasis due to their common cultural and political attributes shared with Finland. Resource limitations are the reason why educational institutions outside of Europe were not included in the review.

The level of information regarding the educational programmes offered is not given in any great depth. This is because this initial review is to be followed by a more detailed evaluation of the considered institutions. Here the compiled information includes: country of programme, name of programme, name of educational institution, internet address, general programme description and subjects of emphasis etc.

3 Methodology

The review had a workforce budget of approximately 280 person-hours distributed among three researchers. The review was conducted within the period of 18 November through to 31 December, 2009. The entire process of searching for existing institution and documenting their programme curriculum was carried out primarily through using the Internet.

A SWOT analysis (i.e. Strengths, Weaknesses, Opportunities, Threats) was done concurrently for the University of Jyväskylä's Renewable Energy (RE) Programme. This gave researchers a good platform for comparison of programmes with other institutes and an indication of what sort of attributes any existing complementary educational programme might have. The SWOT analysis was based on interviews with RE Programme personnel, former and current student feedback and partly based on future prospects of employment for graduates in the Central Finland business sector.

Any review is not without limitations. In this case, the most obvious is the means by which the work was carried out. The Internet is a source of both high-quality and poor-quality information. Likewise, information provided by educational institutions can not be seen as neutral; institutes have an interest in promoting their own programmes. This means that information available on websites is subject to a certain level of propaganda value and is, at best, difficult to evaluate. Additionally, due to the many languages of Europe, a limited amount of web pages exist in English outside those countries where it is spoken more commonly. In these cases, inaccurate information may give the researcher a false impression of reality. Because researchers did not have personal contact with the named institutions, verification of a programme's quality could not be made. Conversely, existing programmes which lacked English-language web pages could not be identified by researchers.

Finally, it is worth noting the available human hours used in this review were extremely modest given the scale of the task involved. The same amount of time could easily be used in a detailed evaluation of a single country's educational institutions.

4 Results

4.1 International bioenergy education in Europe

The findings of this study are listed in the appendix which contains a list of existing programmes and institutes in Europe dealing with, at least partially, bioenergy education. To summarise this list, relevant programmes exist in the following countries: Austria, The Netherlands, Germany, Iceland, United Kingdom, France, Ireland, Estonia, Denmark, Sweden, Belgium, Latvia and Greece. The appendix also contains other information regarding the individual programmes if such information was available from the Internet. The details vary depending on what was available.

A general trend in most of these educational programmes, and indeed the most comprehensive of them, is the assumption that bioenergy and energy in general is the domain of applied science; namely, the engineer. Therefore, it is not surprising that a large number of the programmes have courses dealing with natural sciences and application-oriented objectives. These skills are of course necessary in appreciating renewable energy and bioenergy sectors.

In Finland, four Universities providing international bioenergy related Master degree programmes were found. Other interesting findings were the Nordic Master Programme Innovative Sustainable Energy Engineering and the European Master in Renewable Energy.

Åbo Akademi (ÅA) focus on Chemical Engineering and offer three major subjects: Process Chemistry, Process and Systems Engineering and Pulp and Paper Technology. Students participating in this study programme will strengthen their knowledge in process chemistry, pulp and paper technology and process technology. The study programme is designed solely for students with a bachelor's degree in chemical engineering or corresponding degree.

Lappeenranta University of Technology (LUT) provide Masters programs in Energy Technology: Bio-energy (Minor Subject) and Environmental Energy Technology (Major Subject). The programme objective to educate specialists for demanding tasks in the industrial environment with the knowledge and know-how for the development of new energy efficient and environmentally friendly processes, products and technologies in the future. The curriculum include power plant and steam boiler engineering, pollution prevention, emission reduction, utilisation of by-products as material or energy, waste treatment, recycling and disposal.

University of Jyväskylä (JYU) provides a programme providing a multidisciplinary approach in the renewable energy sector where the Faculty of Mathematics and Science, the Faculty of Social Sciences and the School of Business and Economics cooperate. Study options explore three mains tracks: technology (applied physics, chemistry), sustainable bioenergy (environmental science and technology) and sosio-economics (social sciences).

Aalto university (TKK) in Finland is involved in the Nordic Master Programme Innovative Sustainable Energy Engineering formed under the auspices of the Nordic Council of Ministers, which pools the strengths from energy departments located at the largest technical universities in Sweden (KTH Royal institute of technology in Stockholm and Chalmers in Gothenburg) Denmark (DTU), Norway and Iceland (University of Iceland). Biomass energy is included in the curriculum but not very strongly.

The European Master in Renewable Energy is coordinated by EUREC from Brussels, Belgium. The Master is based 0n a Consortium of Institutions: Ecole des Mines de Paris, France, Zaragoza University, Spain (bioenergy), Loughborough University, UK and Oldenburg University, Germany. The programme objective is to provide a solid foundation in the key energy technologies: wind, solar, bioenergy and

hydropower. Socioeconomic issues are also examined surrounding the deployment of these technologies.

4.2 SWOT analysis of RE Programme

The Master's Degree Programme in Renewable Energy provides education in renewable and distributed energy production in order to promote the utilisation of sustainable energy sources. The programme provides students with a thorough insight into sustainable renewable energy technologies and an understanding of socio-economic factors. The programme was started 2003 as a national education programme with instruction mainly in Finnish but gained an international status in 2007. New bioenergy courses were introduced in 2007 and one of the five study tracks was named "Sustainable Bioenergy".

To really appreciate what is available in terms of renewable energy related programmes elsewhere in Europe, the authors first evaluated Jyväskylä's own Renewable Energy Programme in terms of a SWOT analysis. This is presently below.

4.2.1 Strengths

The fact that a renewable energy programme has already existed in Jyväskylä since 2003 is an obvious strength in itself. Furthermore the educational programme is turning out graduates who are to some extent finding employment in the renewable energy sector. During 1998–2008 the activity in producing bioenergy related thesis was continiously growing: nine PhD thesis and 61 Master thesis was finished within this period of time [2].

The multi-disciplinary nature of the programme is a strength due to the wide range of experiences and backgrounds of students and due to the holistic approach often needed with implementing sustainable energy production.

The greatest single strengths in terms of research output and potential is most likely in biogas technology and dye-sensitised solar cell chemistry. Prof. Jukka Rintala's group has a long history in biogas research. His group has good ties to industry and a long list of publications regarding waste management and biogas production and is continuously producing doctoral students.

Research in dye-sensitised solar cell chemistry, lead by Prof. Jouko Korppi-Tommola, is another well-established and high-level field with a research focus on fundamental chemical and physical processes in this technology.

The RE-Programme has good regional collaboration with other institutes and organisations especially within Central Finland but also nationally. The programme has produced demonstration projects (solar, wind and heat pumps) within Central Finland which has raised public awareness and media attention regarding energy-related issues in the region and nationally, especially in the field of distributed and derived energy production.

A final strength of the programme is its international flavour. Each year of admissions sees several foreign students enrol in the programme and lecturers, steering council members and other staff have been of a foreign background. These multi-national influenced bring fresh perspectives to the programme and assist in promoting Finnish energy initiatives abroad.

4.2.2 Weaknesses

The RE-Programme's non-permanent status as an educational provider is a considerable weakness because long-term strategies have been compromised. This stems from a lack of funding and personnel resources [3] which in itself is a consequence of the programme existing outside the traditional faculty and departmental boundaries of the university. A further weakness stems from this fact. Programme staff members who are themselves based in one department or other have, understandably, interests or loyalties to their home faculty which can lead to conflict of interests in term of the success of the programme. Therefore dedicated programme staff would be desirable especially for programme planning and funding applications. This situation has been considerably improved with the recent appointment of a professor in Renewable Energy.

The diverse backgrounds of the students also weaken the content of the educational programme. An example is the extra resources invested in teaching background studies for students without a former degree in natural sciences. This is especially obvious for students coming from the humanities with little or no technical background. Conversely, students having a good scientific and technical footing (i.e. in physics and chemistry) are slowed up in their studies through having to go through basic issues. The overall result of these two effects is a compromise on both ends of the spectrum; non-technical students struggle with basic technical issues and rarely achieve mastery while technical-minded students never have the opportunity to hone their skills on advanced issues.

Course scheduling can also be seen as a weakness. Lecturers structure their teaching schedule based on the activity in their home faculties. This makes it difficult for students to create an optimal study programme with a suitable amount of courses running frequently during their studies years. Also the small intake for each discipline is a challenge for the educators as many different courses must be offered for students having a diverse educational background.

The knowledge base and quality level of the RE-Programme curriculum is not visible from outside of the programme. Production, especially in terms of research results related to the curriculum, is lacking. This may be simply the result of the multi-disciplined structure of the programme's administration.

Although there are an increasing amount of jobs related to renewable energy in the present workforce, employment prospects for graduates of the programme are not immediately obvious to the students and this probably has an influence on both potential applicants and on the motivation of students.

4.2.3 Opportunities

The RE-Programme has excellent opportunity to be a leading programme in Europe in terms of renewable energy education, especially in the field of solid biofuel production, upgrading, energy production and utilisation. The region's existing bioenergy expertise provide a good base from which to obtained permanent funding because Central Finland is already recognised internationally for its bioenergy networks, research expertise and projects.

The multidisciplinary approach is also rather unique opportunity to further build on. Theoretical studies combined with field work, practical demonstration, hands-on training in bioenergy companies and real research groups can also be provided in future due to good regional cooperation.

One opportunity to rapidly gain a wellknown position is to establish cooperation with both the Nordic Master Programme Innovative Sustainable Energy Engineering and the European Master in Renewable Energy. Also more cooperation within the sustainable energy (KE- Kestävä energia) cooperation framework with the universities in Tampere can be seen as an opportunity.

4.2.4 Threats

Perhaps the greatest threat to the RE-Programme is the possibility of another institution within Finland initiating a similar type programme but with more secure funding and resources and at a greater scale. Poor personnel resources (both lecturers and researchers) are a challenge for even keeping the present level of education running. In terms of quality of education, a general weakening will be a continued threat as long as the programme has to compromise its structure, curriculum and research due to lack of funding.

4.3 Recommendations for further studies

Based upon experience within the RE-Programme in Jyväskylä, the following information would be valuable to collect for the most interesting existing programmes in Europe:

- Key educators in the field of bioenergy (CVs and experience)
- Research activities related to other M.Sc. programmes
- M.Sc. thesis produced & field of research
- The exchange willingness and activity among educators
- Student intake and the amount of graduates with M.Sc. in Bioenergy
- Existence and level of study fees
- Employment profile among graduated students
- Already existing exchange programmes
- The possibilities for PhD studies focusing on Bioenergy

To achieve these recommendations a more extensive examination of European programmes would be required. This would most likely involve, in addition to use of the Internet, telephone interviews with educators and students, e-mail exchange and perhaps research visits to key institutes to examine first-hand the workings of programme.

5 Conclusions

The conclusions that can be draw from this limited study can be expressed concisely as follows:

Renewable energy and bioenergy education has already reached a high level of awareness in Europe. This is reflected in the existence of several international programmes in these fields. The structure of individual renewable energy or bioenergy programmes vary widely. This field of education is often linked to the tehnical (engineer) and natural sciences with good reason and this is reflected in the curriculum of a large part of the available programmes in Europe.

Future development and integration of Jyväskylä's renewable energy programme would require a serious restructuring of available courses and creation of new ones. In order for this to be achieved, future positions in the workforce for programme graduates needs to be defined and a network of work placement in companies could be established. Focus should be set on areas where the programme seems to be most competitative and attractive and where there is possibilities to provide unique input to cooperation with other universities and already established consortiums. For such a task, a much deeper evaluation of European educational institution is required especially in terms of bioenergy.

6 REFERENCES

[1] Bologna Secretariat, Brussels (2010). "Welcome to the website of the European Higher Education Area: The official Bologna Process website 2007-2010". Benelux Bologna Secretariat. **http://www.ond.vlaanderen.be/hogeronderwijs/bologna/**. Retrieved 2010-06-21.

[2] Asplund D, Wihersaari M, Lehtomäki A-M. Jyväskylän yliopiston rooli seudullisessa bioenergiayhteistyössä. Visio vuoteen 2012. Jyväskylä Innovation Oy. 2008. 42 p.

[3] Wihersaari M. Biotalous edellyttää kunnon koulutusta Mielipide-kirjoitus 9.3.2010. Keskisuomalainen.

7 APPENDIX

International Bioenergy Education in Europe – An Overview

The review was conducted within the period of 18 November through to 31 December, 2009 and completed during spring 2010.

CONTENT

1 AUSTRIA

1.1 Industrial Environmental Protection, Waste Disposal Technology and Recycling

http://www.unileoben.ac.at/content/view/5/411/lang,en/

Montan Universität, Leoben, Austria

Program description
Undergraduate program: 7 semesters, thereof 4 semesters efficient education in natural sciences and subject-oriented fields and 3 semesters intensification: professional education in process engineering or supply and waste management technology. Graduate program: 3 semesters, thereof 2 semesters of specialization in industrial environmental engineering + 1 semester for the diploma thesis.

The following electives are offered (2 of them are required): recycling technology, plant technology/planning, contaminated sites, automation, applied business management, industrial plants, energy supply technology, material supply technology, modelling of infrastructure and waste management, simulation in process technology.

1.2 Technical Chemistry

http://portal.tugraz.at/portal/page/portal/TU_Graz/Studium_Lehre/Studien/Techn_Chemie_Master

Graz University of Technology, Austria

The engineering sciences master's programme in Technical Chemistry lasts four semesters and consists of one stage of study. The entire master's degree programme comprises 120 ECTS credits.

Following subject areas are focused on:
- Renewable resources
- Macromolecular chemistry and plastics engineeringSurface and interface engineering

Chemists make important contributions to progress in the field of computing by continuing development of conductors and semiconductors. They work on improving construction materials and provide challenging solutions in architecture and the construction industry. Innovative solutions have also been made in projects dealing with exhaust-air treatment in road tunnels in Graz. Chemistry graduates can work as specially trained poison prevention officers in mineral metallurgy and other highly sensitive fields.

2 FINLAND

2.1 Renewable Energy

https://www.jyu.fi/kemia/tutkimus/uusiutuva-energia/en

Master's Degree Programme in University of Jyväskylä

The Programme concentrates on the multidisciplinary renewable energy sector and is a collaboration between researchers and educators from the Faculty of Mathematics and Science, the Faculty of Social Sciences and the School of Business and Economics.

Education
The Master's Degree Programme in Renewable Energy provides education in the renewable and distributed energy production in order to promote the utilization of sustainable energy sources. The programme provides students with a thorough insight into sustainable renewable energy technologies and an understanding of socio-economic factors.

Research & Demonstrations
The Research Programme in Renewable Energy focuses on the development of distributed energy technologies and uses demonstration projects for promoting public awareness of renewable energy technologies. Projects involve municipalities, research institutes, companies and farms.

Study Tracks
Study options explore three mains tracks:
- technology (applied physics, chemistry)
- sustainable bioenergy (environmental science and technology)
- sosio-economics (social sciences)

In addition to mandatory RE courses, master's degree studies include courses from the faculty of the relevant field of study.

Renewable energy

Fall
Advanced special studies (laudatur)
FYSS390 Technical Thermodynamics, 8 ECTS
FYSS391 Technical Thermodynamics (part A), 4 ECTS
FYSS392 Technical Thermodynamics (part B), 4 ECTS
KEMS801 Renewable Energy Production, 8 ECTS
KEMS810 Solar Energy, 4 ECTS , Reading course
KEMS813 Industrial Processes, 3 ECTS
KEMS848 Advanced Laboratory Practical in Renewable Energy, 8 ECTS
YMPS341 Air Pollution Measurement-Techniques, 3 ECTS
YMPS391 Biomass production and utilisation 4 ECTS
YMPS464 Waste to Energy, 4 ECTS
YMPS492 Bioenergy production: processing and utilisation of by-products, 3 ECTS
Spring
Advanced special studies (laudatur)
KEMS802 Seminar on Renewable Energy, 4 ECTS
KEMS806 Wind Energy Technology, 4 ECTS
KEMS810 Solar Energy, 4 ECTS, Reading course
KEMS848 Advanced Laboratory Practical in Renewable Energy, 8 ECTS

YMPS342 Air Pollution Control Technology I, 3 ECTS
YMPS467 Basics in thermic conversion techniques of biomass, 5 ECTS

Others
Advanced special studies (laudatur)
KEMS812 Energy Policy, 6 ECTS, Reading course
KEMS849 Renewable Energy Research Training, 24 ECTS
KEMS850 Renewable Energy Master`s Thesis, 16 ECTS

Study track: Sustainable Bioenergy, 120 ECTS

Obligatory
KEMS801 Renewable Energy Production, 8 ECTS
KEMS802 Seminar on Renewable Energy, 4 ECTS
YMPS900 HOPS 1 ECTS
YMPS353 Biofuel standards and analysis 4 ECTS
YMPS391 Biomass production and utilisation 4 ECTS
YMPS392 Energy Systems: Carbon, Energy and Emission Balances, 5 ECTS
YMPS467 Basics in thermic conversion techniques of biomass, 5 ECTS
YMPS901 Master`s Thesis, 30 ECTS
YMPS902 Maturity test -

Technology, at least 8 ECTS
YMPS339 Air Pollution Control Technology I, 3 ECTS
YMPS340 Air Pollution Control Technology I, 2 ECTS
YMPS360 Paikkatietojärjestelmät ja spatiaalinen interpolointi 4 ECTS
YMPS450 Biogas technology 4 ECTS
YMPS456 Biofuels for traffic 4 ECTS
YMPS464 Waste to Energy 4 ECTS
YMPS492 Bioenergy production: processing and utilisation of by-products 3 ECTS
KEMA243 Johdatus puunjalostukseen 5 ECTS
KEM601 Puun rakenne ja kemiallinen koostumus 7 ECTS

Economy, at least 8 ECTS
YMPS491 Energy economics 4 ECTS
CEMS210 Material flow management 5 ECTS
CEMS220 Material flow management, computer demos 3 ECTS
CEMS230 Managing a green organisation 5 ECTS
CEMS270 Climate business 5 ECTS

Environment, at least 8 ECTS
YMPS361 Paikkatietojärjestelmien käyttö ympäristövaikutusten arvioinnissa 4 ECTS
YMPS362 Paikkatietojärjestelmien sovellukset ympäristötieteessä 2 ECTS
YMPS413 Ympäristötilastot, kokoaminen ja käyttö 3 ECTS
YMPS432 YVA-kurssi 4 ECTS
YMPS445 Ympäristövaikutusten arvioimisen (YVA) projektityö 5 ECTS
YMPS493 Biopolttoaineiden tuotannon ympäristövaikutukset 2 ECTS
EKOS305 Boreaalisen havumetsävyöhykkeen monimuotoisuus ja erityispiirteet 6 ECTS

Optional 35 ECTS

2.2 Chemical Engineering

https://www.abo.fi/student/en/chemicalengineering

Master's Degree Programme in Åbo Akademi

Students participating in this study programme will strengthen their knowledge in process chemistry, pulp and paper technology and process technology. The study programme is designed solely for students with a bachelor's degree in chemical engineering or corresponding degree.

The Master's Degree Programme in Chemical Engineering has three major subjects:
- Process Chemistry
- Process and Systems Engineering
- Pulp and Paper Technology

The study programme has a total duration of two academic years. Overall, 12 active months of courses and 6 months of thesis work. There is a three-month summer break between the first and second academic year. The academic year starts in September and ends in May.

2.3 Bioenergy Technology

http://www.lut.fi/en/technology/lutenergy/environment/studies/Pages/Default.aspx
http://www.lut.fi/en/technology/lutenergy/studies/energytechnology/Pages/Default.aspx

Lappeenranta University of Technology

The Master's degree programme in Bioenergy Technology responds to the needs of the changing society regarding sustainable energy and environmental engineering in a socially responsible international context. The graduates will have excellent qualifications to work in the development of new energy-efficient and environmentally friendly processes, products and technologies (eg power plant and steam boiler engineering, pollution preventing, emission reduction, waste treatment, recycling).

The Master´s degree programme in Bioenergy Technology covers the following topics:
- sustainability in energy production
- design of power engines in renewable energy
- emission reduction methods
- techniques of integrating environmental issues into decision-making processes
- technical and economical possibilities to use bioenergy technology solutions.

The extent of studies for the degree of Master of Science (Tech.) is 120 ECTS credits.

Major Subject: Environmental Energy Technology

The major subject focuses on reducing the environmental impacts of energy production, such as energy production technologies using different types of renewable fuels and new pollution control technologies. A graduate from the programme will also be familiar with environmental management systems and corporate responsibility. Our aim is to educate specialists for demanding tasks in the industrial environment with the knowledge and know-how for the development of new energy efficient and environmentally friendly processes, products and technologies in the future. Teaching is focused on power plant and steam

boiler engineering, pollution prevention, emission reduction, utilisation of by-products as material or energy, waste treatment, recycling and disposal.

Minor Subject: Bioenergy Technology

The minor subject of this Master´s programme is focused on bioenergy systems. It includes topics such as biofuel production and refining technologies, bioenergy end-use technologies and international trade of biofuels.

3 GREECE

http://www.ntua.gr/postgraduate2_en.html

3.1 Energy generation and management

http://www.epm.ntua.gr/en_programcontents.aspx

National Technical University of Athens

With two directions:
- Renewable Energy Sources and Rational Use of Energy
- Energy Plants and Transports

The Inter – Departmental Postgraduate Course "Energy Production and Management", co-ordinated by the National Technical University of Athens (NTUA), aims at the systematic professional development of mechanical engineers in the field of energy production and management. Rapid developments in energy technology, new priorities in energy consumption policy and modern requirements in the marketplace render specialization in this field, which is characterized by a multidisciplinary nature, necessary. The Programme offers a full postgraduate education in the following areas:

Energy Production
- Renewable energy sources
- Power plants and electricity production system
- Fuels (carbon, oil, natural gas, bio-fuel, bioethanol etc)

Energy Use
- Energy and housing constructions (passive and active design of heating and cooling systems, housing constructions with a minimum loss, energy management systems etc)
- Energy and industrial installations (thermal electric applications, cogeneration, recuperation of heat etc)
- Energy and transportation (conventional means of transport, electric drive etc)

Energy Saving
- Energy management (automatic control systems, measuring systems, accounting methods)
- Energy saving and programming

3.2 Environment and development

http://www.survey.ntua.gr/main/studies/environ/brief.pdf

National Technical University of Athens

4 LATVIA

4.1 Environmental Science

http://www.rtu.lv/content/view/2027/1237/lang,en/
http://www.rtu.lv/index.php?option=com_docman&task=doc_download&gid=1828

Riga Technical University

A. COMPULSORY COURSES 35 CP
1. Environmental Protection Problems 4 CP
2. Heat and Mass Transfer Processes and Technologies 12 CP
3. Energy Technology. Advanced course 6 CP
4. Environmental Management 4 CP
5. Environmental Policy of UN 4 CP
6. Ecodesign 4 CP
7. Basics of Occupational Safety 1 CP

B. LIMITED CHOICE 21 CP
1. Specialized courses 17 CP
1.1. Ecological Aspects of Energy Efficiency 4 CP
1.2. Modelling of Thermal Systems and Processes 6 CP
1.3. Energy Conversion and Efficiency 4 CP
1.4. Climate Change. Modelling 4 CP
1.5. Optimisation of Electric Supply 4 CP
1.6. Heat Supply Optimisation 4 CP
1.7. Environmental Impact Assessment 4 CP
1.8. Air Technologies Pollution Reduction 4 CP
1.9. Renewable Energy Resources 4 CP
1.10 Ecological Aspects of Energy Technology 9 CP
1.11 Life Cycle Analysis 2 CP
1.12 Environmental Audit 2 CP
1.13 Environmental Chemistry and Technology 2 CP
1.14 Water Chemistry and Microbiology 2 CP
1.15 Innovation Strategy Management 3 CP
1.16 Recycling of Industrial Waste 2 CP
2. Humanities and social sciences 4 CP
2.1. Environmental Economics 4 CP
2.2. Socio-economic Aspects of Energy Supply 4 CP
2.3. Presentation Skills 2 CP
2.4. Sociology of Business 2 CP
2.5. Contact Psychology 2 CP
2.6. Social Psychology 2 CP

C. FREE ELECTIVES 4 CP
E. FINAL ASSESSMENT 20 CP
1. Master Thesis 20 CP
TOTAL: 80 CP

5 SWEDEN

5.1 Sustainable energy engineering

http://www.kth.se/studies/master/programmes?l=en_UK
http://www.kth.se/studies/master/programmes/me/2.1746?l=en_UK

Mechanical engineering in KTH Royal institute of technology, Stockholm

The purpose of the SEE Programme is to provide state-of-the-art education in the fields of solar energy, power generation, and energy utilization in the built environment by means of economically and environmentally sustainable systems and technologies. Strong emphasis is placed on dealing with energy engineering tasks with due consideration of technical, environmental and socio-economic issues.

	Semester 1	Semester 2
Year 1	Introduction to Energy Technology	Applied Energy Technology, Project Course
	Sustainable Energy Utilization	Energy Management
	Sustainable Power Generation	Applied courses in either:
	Renewable Energy Technology	Sustainable Power Generation (SPG),
	Energy and Environment	Sustainable Energy Utilization (SEU), or
		Solar Energy (SOL, in conjunction with Dalarna University College, Campus Borlänge)
Year 2	Numerical Methods in Energy Technology	Degree project
	Measurement Techniques in Energy Technology	
	Theory and Methodology of Science	
	Additional advanced electives	

5.2 Sustainable technology

Mechanical engineering in KTH Royal institute of technology, Stockholm

The Master's programme in Sustainable Technology has a total duration of 2 years, divided in 4 terms. The programme is built up of 3 terms of theoretical courses which amount to 90 ECTS credits. Compulsory courses amount to 55,5 ECTS and 34,5 ECTS are from elective courses.

	Semester 1	Semester 2
Year 1	Compulsory courses:	Compulsory courses:
	Introduction Industrial Ecology, 6 ECTS	Cleaner Production, 6 ECTS
	Ecology, 6 ECTS	Environmental Management, 6 ECTS
	Environmental Effects from Technical Systems and Processes, 6 ECTS	Ecological Economics, 6 ECTS
	Environmental System Analysis, 6ECTS	Elective courses:
	Technology and Sustainable Development , 6 ECTS	Risk Management, 6 ECTS
		Waste Management, 6 ECTS
		Environmental Technology, 6 ECTS
		Environmental Consequences II, 6 ECTS
Year 2	Compulsory courses:	Degree project, 30 ECTS
	Research Methodology and Theory of Science, 7,5 ECTS	
	Elective courses:	
	Cleaner production II, 6 ECTS	
	Applied Environmental System Analysis II, 6 ECTS	
	Environmental management II, 6 ECTS	
	Sustainable Development in Theory and Practise, 6 ECTS	
	Environmental Modelling: Introduction and application examples, 6 ECTS	
	Scenario Methods, 6 ECTS	
	Renewable Energy Technology, 6 ECTS	
	Sustainable Energy Utilisation, 9 ECTS	
	Sustainable Power Generation, 9 ECTS	

5.3 Innovative Sustainable Energy engineering

http://www.nordicmaster.eu/

Mechanical engineering in KTH Royal institute of technology, Stockholm

This new MSc programme, formed under the auspices of the Nordic Council of Ministers, pools the strengths from energy departments located at the largest technical universities in Sweden, Denmark, Norway, Finland, and Iceland. The purpose of the programme is to provide state-of-the-art education in the fields of conventional and renewable energy sources and new power generation, such as solar energy, biomass energy, wind power, geothermal power, and energy utilization in the built environment by means of economically and environmentally sustainable systems and technologies.

	Semester 1	Semester 2
Year 1	Introduction to Energy Technology	Studies at either KTH, Chalmers, or at a partner university in Denmark (DTU), Finland (TKK) or Iceland (University of Iceland)
	Renewable Energy Technology	
	Sustainable Power Generation	
	Sustainable Energy Utilization	
	Energy and Environment	
Year 2	Studies at either KTH, Chalmers, or at a partner university in Denmark (DTU), Finland (TKK) or Iceland (University of Iceland)	Degree project

5.4 Resource Recovery – Sustainable engineering

http://www.hb.se/wps/portal/
http://edu.hb.se/utbildning/utbprogeng.asp?ptkod=KMAKB08h
http://www.hb.se/wps/portal/!ut/p/c1/hc1NDoIwEIbhs3iCTlsoZVkEhkZ-REJFNo-QFIU0EXBjPL8SdiTjf8smbIS1ZN_cvO_ZPu8z9nTSkFV3snEJTCQ5Sej5orFNwg4qxC139Jrq8YHXsaEqliCgwkThBajRgyP_U1-3ffr85_DgFH4-ypPYDqgCi0gPGEU2e6lDgvmfo7veGfXmhTLy6VEdeKg4oSJ4s00CqYSaPqQGr7XlUh8Mbt-7h4A!!/dl2/d1/L2dQX2cvSU5qQUFBaUlpSWIJZ0EhIS9ZQnB4cHhweHB4cHhweHB4cHcvNl9FTUhVOUIxQTBPQVZGMDIzOEFDM1FBMzBRMA!!/?TERMIN_PARAM=20102&ANMKOD_PARAM=KMARE10h1

University of Borås, Sweden, M.Sc. *(Erasmus mundus)*

Content:

The education is aimed at providing the student with skills and knowledge to be able to develop and introduce sustainable systems and technology in the material, energy and recycling sectors. The central focus of the programme is resource management and recycling of materials. The education also aims at preparing the student for PhD studies.
A broad spectrum of different areas of engineering will be studied. To analyze and compare different alternatives of waste treatment life cycle assessment becomes an important tool. Skills in oral and written presentations are vital, too, if ideas and thoughts are to be commu-

nicated and applied successfully. The studies are strongly connected to the research areas bioethanol, biogas, biopolymers and energy recovery.

The courses that the programme comprises are listed below:

Study year 1
Overview of a Sustainable Development
Sustainable Materials
Resource Recovery
Process Technology
Risk Management in Processing and Transportation of Waste and Residual Products
Energy Recovery
Life Cycle Assessment
Biofuels and Biological Treatments of Wastes

Study year 2
Measurements and Statistics
Process Design - Recovery of Energy and Material Resources, 15 ECTS
Research Project - Resource Recovery
Degree Thesis, 30 ECTS credits

6 BELGIUM

6.1 European Master in Renewable Energy

http://master.eurec.be/

Brussels, Belgium (Coordinator)

The course's three sections
The core provides a solid foundation in the key energy technologies (wind, solar, bioenergy, hydropower). Theoretical courses which also examine the socioeconomic issues surrounding the deployment of these technologies are supported by laboratory workshops. The studies for the core can be done in French, English or Spanish.

The student can choose one of the following:
- Ecole des Mines de Paris, France for the core taught in French
- Zaragoza University, Spain for the core taught in Spanish
- Loughborough University, UK for the core taught in English
- Oldenburg University, Germany for the core taught in English

A specialisation focused on a particular technology or implementation aspect selected from: Photovoltaics; Wind power; Energy Conservation in Buildings; Bioenergy and Hybrid systems. The specialisations are taught in English.

The student can choose one of the following:
- National Technical University of Athens, Greece for the specialisation in Wind Energy
- Zaragoza University, Spain for the specialization in Bioenergy
- Kassel University, Germany for the specialisation in Hybrid Systems
- University of Northumbria, UK for the specialisation in Photovoltaics
- University of Athens, Greece for the specialisation in Energy Conservation in Buildings

A project related to the specialisation taken and undertaken in industry, a research laboratory or at the university and during which the student can gain practical or research experience

7 NETHERLANDS

7.1 Master's Programme: Energy Science

http://www.uu.nl/EN/informationfor/internationalstudents/energyscience/Pages/study.aspx

Universiteit Utrecht, Netherlands

The Master's programme in Energy Science studies the sustainability of the production, treatment and use of energy and materials. The programme gives you detailed insight into the development of energy and material use over time, into current and future energy technologies (including renewable energy), such as solar cells, biomass and wind, and into bio-based materials and energy and climate policies. Graduates will be able to contribute to the transitions towards sustainable energy and material systems by doing applied research or consultancy work or by giving policy advice.

Typical questions that are addressed in the Master's programme in Energy Science are: When will solar energy become a competitive alternative to fossil fuels? Is it better to recycle plastic or to burn it? What is more important: renewable energy or energy conservation? And what can be achieved with fuel cells?

Energy Science is a 2 year full-time Master's programme (120 ECTS), consisting of 52.5 mandatory courses, 15 ECTS optional courses and 67.5 ECTS of research projects.

Mandatory courses:
Energy and Resources Policies (7.5 ECTS)
Sustainable Development - An Integrated Systems Approach (7.5 ECTS)
Energy Conversions and Environmental Technology (7.5 ECTS)
Research Methods for Energy and Materials (7.5 ECTS)
Energy Modelling and Economics (7.5 ECTS)

Optional courses
Energy analysis or Optional course 1 (7.5 ECTS)
Optional course 2 (7.5 ECTS)

Research projects
Consultancy project (15 ECTS)
Master thesis (30 ECTS)
Internship (22.5 ECTS

7.2 Environmental engineering

Wageningen University, Netherlands, M.Sc.

The MSc programme Environmental Sciences of Wageningen University in an **international** programme that offers students advanced and specialized academic training emphasising the development of:

- A critical attitude;
- Analytical and problem-solving skills;
- In-depth knowledge of a wide range of environmental and sustainability issues

Results from the National Students Survey of 2007 show that students are very pleased with this programme. With an average score of 8.2, MSc Environmental Sciences is choosen to be the **best judged MSc programme** offered by Dutch research Universities. Check MES Students Survey 2007 (pdf 30kb) for the scores.

Nine different majors are offered within this programme. Use the links to find a detailed description of the research area and the courses that are part of these majors. The majors are divided into four groups:

- Environmental quality: aquatic ecology and water quality management, soil quality, meteorology and air quality, and environmental toxicology;
- Environmental Systems Analysis: environmental systems analysis;
- Environmental management and policy: environmental policy, environmental economics, and integrated water management;
- Environmental Technology: environmental technology;

7.3 Sustainable energy technology

http://w3.tue.nl/en/services/cec/study_information/masters_programs/sustainable_energy_technology/
http://www.3tu.nl/fileadmin/3tu/3TU_Broch_SET_febr2009.pdf
course structure:
http://w3.tue.nl/en/services/cec/study_information/masters_programs/sustainable_energy_technology/course_structure/

Eindhoven University of Technology, Netherlands, M.Sc.

The Master's degree program is offered by the Dutch '3TU federation' of TU Eindhoven, TU Delft and the University of Twente.

The multidisciplinary research in the field of sustainable energy technology is organized into six themes. You can graduate in one of these themes.

- energy from biomass
- solar energy
- wind energy
- hydrogen technology
- electrical power engineering
- energy and society

The program is a joint initiative of the following 6 departments:

- Mechanical Engineering
- Applied Physics

- Chemical Engineering and Chemistry
- Electrical Engineering
- Architecture, Building and Planning
- Industrial Engineering & Innovation Sciences

The Sustainable Energy Technology discipline combines a number of tracks and is based on research carried out by the six participating departments. Research groups from these departments combine sustainability with research in the field of energy technology. Focal areas are photovoltaic solar energy, energy from biomass, hydrogen technology, electrical energy technology and system innovation. The department of physics, for example, carries out research into PV solar cells. The efficiency of solar cells is being improved by the use of plasma to deposit thin layers. In the Mechanical Engineering department the process of the combustion and gasification of biomass is optimized using simulation. This department also houses the biomass lab, where several departments carry out their experiments. The `power quality lab´ at the Electrical Engineering department researches the connection of distributed generation to the electrical network.

The Master's degree program Sustainable Energy Technology lasts two years and consists of 120 EC (European Credit Transfer System).

8 GERMANY

8.1 Renewable Energy Management (REM)

http://www.zee-uni-freiburg.de/index.php?id=26&L=1

Albert-Ludwigs University of Freiburg, M.Sc.

The Renewable Energy Management coursework is very concentrated and is taught in three-week modules. Students will not have to listen to conventional lectures from one tutor only. They will instead be taught by teams of lecturers recruited from departments of seven different faculties, from external research institutions and from the private sector. 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).

First semester (five modules):
1. Energy and sustainable development
2. Natural resources
3. Technology of renewable energy utilisation (part 1)
4. Climate and energy
5. Case study/project

Second semester (4 modules + internship)
1. Societal framework for REM (law, business and politics)
2. Management (part 1)
3. Technology (part 2) including energy efficiency
4. Elective 1 (bio energy, energy efficiency, photovoltaics)

Third semester (5 modules + internship)
1. Management (part 2)
2. Student-organised event
3. Research skills
4 Elective 2 (bio energy, energy efficiency, photovoltaics)
5. Project
Fourth semester: Master's thesis

MODULE HANDBOOK:
http://www.zee-uni-freiburg.de/fileadmin/PDF/REM_Module_Handbook_2009_10.pdf

8.2 Renewable Energy

http://www.ppre.uni-oldenburg.de/

Institute of Physics (Carl von Ossietzky), University of Oldenburg, M.Sc.

The postgraduate programme consists of lectures, seminars and laboratory courses at the University and an external practical training in relevant organisations, research institutes and companies. Necessary theoretical knowledge and practical skills (e.g. for lab work) are acquired during the first term from October to February. The winter term is followed by the mandatory external training in companies or research institutes of two months duration.

The second term (summer term) is dedicated to case studies and the development of solutions to specific problems in rural regions of the Third World. In addition classes on theory and applications of Renewables as well as laboratory courses (solar/outdoor) are continued.

The subject of the final thesis evolves from the participant´s special interest, the laboratory courses and experience gained during the external training, which should be related to the participant´s future professional occupation.

Overview of Modules
Renewable Energy Basics (7 CP)
Wind Energy (7 CP)
Solar Energy (7 CP)
Energy Meteorology & Storage Technologies (7 CP)
Energy Systems & Society (7 CP)
Biomass & Hydro Energy (7 CP)
Case Study (7 CP)
Specialisation (2 CP)
External Practical Training (9 CP)
Master Thesis (30 CP)

9 ICELAND

9.1 Renewable energy science

http://www.res.is/

The School for Renewable Energy Science, Akureyri, Iceland, M.Sc.

RES's main academic objective and goal is to offer excellent education programs in renewable energy science and technologies, and to strengthen future cooperation between leading Icelandic and European academic and research institutions in the utilization of renewable energies.

RES is a new private institution of higher learning established in April 2007. The school offers an intensive one-year (12 months) MSc Program in Renewable Energy Science. The program is offered in cooperation with two public universities in Iceland, The University of Iceland and The University of Akureyri, as well as in partnership with a number of leading technical universities in Europe. See a list and contact information for our partner universities here.

First trimester (15 weeks and 30 ECTS)
Includes a comparative analysis of renewable and non-renewable energy sources, highlighting some of the main physical, chemical and technical aspects of each energy source; an overview of the methods of exploration, exploitation, and technical aspects of utilization of all the different forms of renewable energy sources; in addition to environmental impacts of use, social and economic considerations, and EU renewable energy policies.

During the first trimester students also take part in a 10 day study tour to locations in Iceland where renewable energy is being utilized. After completing the trimester students will acquire strong background knowledge on renewable energy science and technology, and will also generate an appreciation for the interrelationship between the various disciplines necessary for successful execution of renewable energy projects, from the initial exploration to the stages of implementation and utilization.

Second trimester (15 weeks and 30 ECTS)
Emphasis is on a detailed analysis and feasibility studies within the chosen specialisation:

- Geothermal Energy
- Fuel Cell Systems & Hydrogen
- Biofuels & Bioenergy
- Hydropower
- Wind & Wave (Tidal) Power
- Solar Energy
- Energy Systems & Policies

Third trimester (15 weeks and 30 ECTS)
During this trimester students will complete their Master Thesis (30 ECTS). Each student will present his/her findings with a formal presentation at RES.

Contents: Biofuels & Bioenergy
First trimester (February - June)
RES601 Energy - Past, Present, and Future
RES602 Energy Technologies - Conversion, Storage & Energy Systems

RES604 Life-Cycle Assessment & Energy Efficiency Analysis
RES603 Carbon Capture & Sequestration Technologies
RES605 Geothermal Energy
RES606 Fuel Cell Systems & Technologies
RES607 Hydropower
RES608 Biofuels & Bioenergy
RES609 Solar Energy
RES610 Wind & Wave (Tidal) Power
RES611 Study Tour

Second trimester (June - October)
BIO601 Chemistry & Biochemistry of Biomass
BIO602 BioDiesel
BIO603 BioMethane
BIO604 BioEthanol & BioHydrogen
BIO605 Bioenergy Systems
BIO606 Direct Biomass Combustion & Co-Firing Technologies
BIO607 Gasification & Pyrolysis Technologies
BIO608 Policies & Future R&D of Biofuels & Bioenergy

Third trimester (October - February)
During the last trimester students will complete their Master's Thesis (30 ECTS). The trimester starts with a short module detailing research methods and practical skills in thesis writing

Admissions
The applications are accepted on qualification and first-come/first-served basis. i.e. in case of equal qualification of two applicants, the early applicant is given the place. Therefore it is recommended to apply as soon as possible, well before the deadline. Students can send their completed application form and CV before the other documents in order to secure a place.

Candidates for admission should send the following documents:
1. Please note that in the completed application form, qualifications must be explained clearly, especially if the applicant studied in a non-EU country.
2. A CV (resume) in English.
3. Certified copies of the university diploma and transcripts. Non-certified copies of the university diplomas will not be considered valid.
4. Two letters of reference to RES The School for Renewable Energy. The student should insure that the letters reach the RES Admission Office by the deadline.
5. A proof of English language proficiency.
6. Any additional information in support of your application is welcome but not requested (e.g. information on work experience). If you are an employee and envisage to re-orientate your career into renewable energy, a covering letter outlining your motivations to participate in the course would be very useful.

Admission requirements
A minimum requirement for admission to the M.Sc. Program in Renewable Energy Science is a B.Sc. degree with top grades in engineering or physical/natural sciences (chemistry, physics, geology and related fields). Students will have to demonstrate a good understanding of English, both in reading and writing. An admission committee will review student applications, transcripts, and interview students for the final selection.

The selection process will be competitive as a max. of only 50-70 students will be accepted to the school each year from our foreign partner universities, at least during the first few years of operation. The majority of the students will be coming from eastern, central and southern European countries on full scholarships (i.e. EFTA support). Some of the students have already completed their Masters degrees, and are seeking a second master in renewable energy science and/or are using the coursework and research in Iceland as part of their Ph.D. studies at their home institution.

RES tution fees for MSc studies in 2009 - 2010

- Educational fees: €8.000
- Books: €1.000
- Orientation: €2.000
- Facilities: €7.800
- **Total tution: €18.800**

Contact Information

For more information on the RES Graduate School, please contact:
Mr. Arnbjörn Olafsson
Director of International Affairs
arnbjorn.olafsson@res.is
tel: +354 690 6651

10 UNITED KINGDOM

10.1 Carbon Management

http://www.gla.ac.uk/departments/dumfriescampus/postgraduatestudy/carbonmanagement/

University of Glasgow, UK, M.Sc.

Core courses

- Climate, carbon and change
- Theory and principles of sustainability
- Carbon auditing and management
- Either Environmental and organisational ethics or Policies for sustainability and development.

Optional courses

- Climate change: impacts on ecology
- Environmental economics
- Sustainable buildings
- Sustainable energy technologies
- Tourism sustainability and climate change

You will also complete either a work placement project or dissertation.

10.2 Electrical technology for sustainable and renewable energy systems

http://pgstudy.nottingham.ac.uk/postgraduate-courses/electrical-technology-for-sustainable-and-renewable-energy-systems-masters-msc_223.aspx

Electrical and electronic engineering, University of Nottingham, UK, M.Sc.

Course Content
During the autumn and spring semesters, you will complete 120-credits´ worth of taught modules. This will include the following core modules:

- Power Electronics 2 with project
- Power Networks with project
- Control 2
- Induction Motor Drives with Laboratory
- Power Quality and EMC with Laboratory
- Special Drives
- Hydrogen Economy

In addition, you will be able to choose 30-credits´ worth of modules from the following list:

- Conservation and Recycling of Materials
- Fuel Technology
- Renewable Energy Technology 1
- Combined Heat and Power
- Energy Management
- Renewable Energy Technology 2

Please note that all module details are subject to change.
After completing the taught components of the course, you will undertake a major piece of advanced independent research under the supervision of a specialist in your chosen area. We will provide you with advice and guidance while you select and refine your area of study, and offer close supervision and support as you complete your research and your MSc.

Course Structure
The MSc in Electrical Technology for Sustainable and Renewable Energy Systems is taught on a full-time basis over 1 year. This course is operated on a modular basis and consists of two semesters during which you will follow a series of taught modules (worth 120 credits), followed by a 60-credit research project undertaken during the summer period.

Duration: 12 Months
Annual Tuition Fee: € 5,300.00

10.3 Renewable energy and the built environment

http://www.uel.ac.uk/cite/programmes/postgraduate/renewables-msc.htm

University of East London, UK, M.Sc.

This programme examines the theory and practice of renewable energy technologies with special reference to the built environment. It ranges from the political, economic and social background of energy issues, including global examination of energy provision and con-

sumption and climate change, to local environmental considerations. The theory and practice of renewable energies are examined through both practical work and lectures, enabling you to critically analyse the benefits and drawbacks of renewable energy systems.

The MSc comprises a range of modules, each of which has options depending on the level of practical content you wish to take. This enables you to shape the programme to your requirements. However, you will be required to take at least one practical module. Subjects covered by the modules include:

- Introduction (core)
- Dissertation (core)
- Biomass
- Hydroelectricity
- Photovoltaics
- Solar Thermal
- Windpower.

Duration: 12 Months

10.4 Renewable Energy and Architecture

University of Nottingham, UK

Course Content
During the autumn semester, you will be given a good background on the course subject and on the use of a number of powerful computer programs (e.g. Fluent, Ecotect, IES and ArchiCAD).

Core modules in this semester are:
- Advanced Environmental Design
- Renewable Energy Technology
- Ventilation in Architecture and Planning
- Building Design in Different Climates (option for architects)
- Energy Efficient Systems (option for engineers)

In the spring semester, you will undertake laboratory work and design and simulation projects related to the course area; you will also learn how to write computer programs using Visual Basic.

You will take the following core modules over the spring semester:
- Renewable Energy Technology 2
- Solar Architecture for Different Regions
- Renewable Research Project
- Management of Renewable Technology

Please note that all module details are subject to change.

With the knowledge and experience gained during the course, you will then undertake an individual piece of high-quality research in the form of a dissertation over the summer months.

Course Structure
The MSc in Renewable Energy and Architecture can be taken on a full-time basis over one year (September to September) or part-time over two years. During the autumn and spring semesters, you will complete a total of 120 credits´ worth of modules taught by staff from architectural and engineering backgrounds. Finally, MSc students will complete a written dissertation (worth 60 credits) on an individually chosen topic during the summer period at the end of the course.

10.5 Renewable energy, enterprise and management

http://www.ncl.ac.uk/sage/postgrad/taught/reem/

Faculty of Science, Agriculuture & Engineering, Newcastle university, UK

This new programme is designed for students from a range of backgrounds who want to develop knowledge and expertise in renewable energy. The programme covers issues such as: the social, political and economic climate in which renewable energy must work; the environmental impact of renewable energy exploitation; and planning and managing the future development and direction of the renewable energy industry.

This programme is delivered by a combination of distance learning and one-week intensive schools. All students take compulsory modules in: renewable energy resources and technology; and enterprise and entrepreneurship (40 credits).

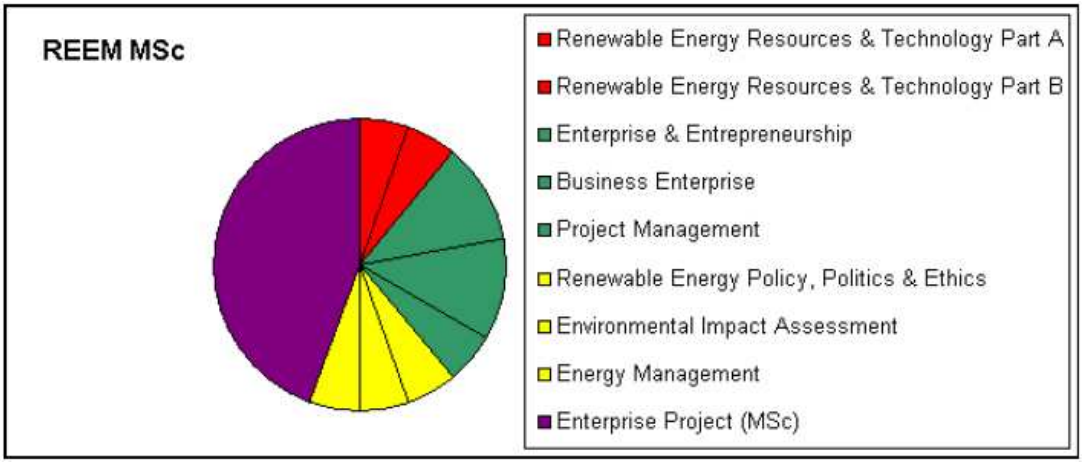
Certificate, Diploma and MSc students then take a further 20, 40 and 60 credits of modules, respectively, from the following list: business enterprise (20 credits); project management (10 credits); energy management (10 credits); renewable energy policy, politics and ethics (10 credits); and environmental impact assessment (10 credits).

Diploma and MSc students then undertake a research project which is worth 40 credits and 80 credits respectively.

Taught modules
SPG8009Renewable Energy Policy, Politics and Ethics (10 credits)
MST8010Project Management (10 credits)
SPG8012Renewable Energy: Energy Management (10 credits)
SPG8013Environmental Impact Assessment (10 credits)
SPG8014Renewable Energy Resources & Technology A (10 credits)
SPG8015Enterprise & Entrepreneurship (20 credits)
SPG8016Business Enterprise(20 credits)
SPG8017Renewable Energy Resources & Technology B (10 credits)

The course schedule for 2009-2010

1. **SPG8014 Renewable Energy Resources & Technology Part A**
2. **SPG8017 Renewable Energy Resources & Technology Part B**
3. **SPG8015 Enterprise and Entrepreneurship part 1**
4. **MST8010 Project Management**
5. **SPG8015 Enterprise and Entrepreneurship part 2**
6. **SPG8016 Business Enterprise for Postgraduates1**
7. **SPG8009 Policy, Politics and Ethics**
8. **SPG8013 Environmental Impact Assessment**
9. **SPG8016 Business Enterprise for Postgraduates 2**
10. **SPG8012 Energy Management**



10.6 Renewable energy (flexible training programme)

http://www.ncl.ac.uk/sage/postgrad/taught/reflex/

Faculty of Science, Agriculuture & Engineering,Newcastle university, UK

This programme, approved by the Energy Institute, IMarEST, IMechE, and IET, is specifically designed to meet the needs of an expanding and developing renewable energy industry in the UK and beyond.

It provides fully integrated training in mechanical, electrical, chemical, marine/offshore engineering; photovoltaics and geothermal energy; economics and policy to ensure students receive a comprehensive understanding of the complete renewable energy technology industry.

For the MSc you take 12 compulsory modules (120 credits) and a research project and report (60 credits). For the Diploma you take nine modules (90 credits) and a research project and report (30 credits). For the Certificate you take six modules (60 credits).

Each module is delivered by a combination of distance learning and a one-week intensive school. There are 12 renewable energy modules that cover: resources; photovoltaics and geothermal energy; marine and offshore devices; marine and offshore structures and systems; electrical generation systems; grid systems; energy management; policy, politics and ethics; mechanical power transmission; wind and hydro-energy technology; hydrogen and fuel cell technology; biomass and waste technology. Each module offered is also designed as a stand-alone CPD module.

The Master of Science in Renewable Energy is offered as part of the Renewable Energy Flexible Training Programme (REFLEX). The programme can be undertaken in a full time or part time mode or as a combination of both. The taught element of the programme is delivered by a combination of distance learning and one week intensive schools. Both elements are compulsory.

The full time programme of study lasts for one year and begins annually at the start of Semester 1 in September. The part time programme of study can begin at any time, with ap-

proval from the Degree Programme Director and may be studied for a period of up to 5 years.

Candidates shall take the all of the following modules:

- Credits Title 10
- Resources 10
- Generation and Energy Conversion 10
- Grid Systems 10
- Electrical Generation Systems 10
- Wind and Hydro Energy Technology 10
- Mechanical Power Transmission 10
- Marine & Offshore Structures & Systems 10
- Marine and Offshore Devices 10
- Hydrogen and Fuel Cell Technology 10
- Biomass and Waste Technology 10
- Policy, Politics and Ethics 10
- Energy Management 60
- Masters Project and Report

The REFLEX schedule for 2009-2010.

Module 1: SPG8001 Resources
Module 2: SPG8002 Photovoltaics & Geothermal Energy
Module 3 SPG8004 Grid Systems
Module 4 SPG8003 Electrical Generation Systems
Module 5 SPG8005 Mechanical Power Transmission
Module 6 SPG8006 Wind & Hydro Energy Technology
Module 7 SPG8007 Hydrogen & Fuel Cell Technology
Module 8 SPG8008 Biomass & Waste Technology
Module 9 SPG8009 Policy, Politics & Ethics
Module 10 SPG8010 Marine & Offshore Devices
Module 11 SPG8011 Marine & Offshore Structures & Systems
Module 12 SPG8012 Energy Management

10.7 Renewable energy engineering

http://engineering.kingston.ac.uk/courses/postgraduate/degrees/renewable_energy_engineering_msc.htm

Faculty of engineering, Kingston university, LONDON, UK

The course combines specialist skills to provide career pathways in the following areas of project engineering and management:
* Solar power engineering design and development
* Wind power engineering design and development
* Bio-fuel technologies
* Renewable energy business and management

Optional modules introduce you to subjects designed to help further enhance your career ambitions. The MSc project gives you the opportunity to choose a field of study in which to establish yourself as a specialist. You will be given a wide range of projects, many of which are associated with real-world problems in the engineering industry.

Advanced topics such as 3D solid modelling, virtual product design and simulation and Finite Element Analysis allow you to gain further practical and theoretical knowledge of analytical software tools used in product design. There will also be plenty of opportunities for you to engage in laboratory and group activities. Attendance Delivered in one-week blocks.

Please note that this is an indicative list of modules and is not intended as a definitive list.
Core modules

- Renewable Energy Systems
- Renewable Energy Technology
- Solar Power Engineering
- Wind Power Engineering
- Individual Project

Engineering Design and Development pathway: option modules (choose four)

- Advanced Materials Processing
- Computerised Fluid Dynamics
- Computer Aided Product Design
- Industrial Systems and Management
- Integrated CAD/CAM Systems
- Mechatronics and Automation

Project Engineering and Management pathway: option modules (choose four)

- Business Resource and Management
- Finance Resource Management
- Industrial Project Management
- Industrial Systems and Management
- Integrated CAD/CAM Systems
- Mechatronics and Automation

10.8 Renewable energy and resource management

http://www.glam.ac.uk/coursedetails/685/436

Faculty of Health, Sport and Science, University of Glamorgan, Pontpridd, UK, M.Sc.

This course addresses current worldwide concerns about climate change, renewable energy supply, low carbon economy, and sustainable management of water and solid resources. It will provide a close insight into hydrogen as a fuel vector for the future. This course will develop leading-edge knowledge and high-level practical skills relevant to many areas of post-graduate employment (ie. in managerial, regulatory, scientific and technological roles, related to energy and the environment). The course is delivered on a modular basis mainly by members of the Sustainable Environment Research Centre (SERC), a UK-leading and internationally recognised centre for over 30 years.

This course will increase your knowledge and understanding of the generation and provision of renewable energy and water, wastewater treatment and solid wastes management. You will become familiar with a variety of environmental, social and economic impacts of policy and legislation, renewable energy technologies, waste management hierarchy and techniques, water and wastewater treatment. The course will also train you in relevant computing software and analytical and monitoring equipment used by regulatory institutions, analytical laboratories, and consultancy and technology companies.

COURSE CONTENT:

- Hydrogen - Fuel Vector for the Future
- Renewable Energy 1 - Hydro, Tidal, Wave and Bio-energy
- Renewable Energy 2 - Wind, Solar and Geothermal
- Solids Resource Management
- Water and Wastewater Treatment Processes
- Energy and Environmental Policy and Legislation

You will also conduct a substantial project, usually in conjunction with industries in the region, energy/environmental consultancy firms, governmental regulatory agencies, local authorities or within SERC.

10.9 Renewable Energy Development

http://www.postgraduate.hw.ac.uk/course/242/

Institute of Petroleum Engineering, Heriot-Watt University, Edinburgh, UK, M.Sc.

The 12-month full time MSc course is based on the successful completion of seven core modules, three elective modules and a dissertation. While the core and elective modules provide a broad sweep of knowledge the individual research dissertation gives time for in-depth specialisation in a particular area of interest. The modular structure is summarised below:

Course Modules

Each student must successfully complete the following core modules:-

- **Energy in the 21st century** - Sets the context for the rest of the course. Patterns of energy use and demand, energy resources. Politics of energy, policy initiatives and global warming.
- **Economics of Renewable Energy** - The pricing mechanism and energy. Economics of extracting energy. Economic instruments for the environment: pollution taxes, tradable pollution permits, and environmental valuation. Economic incentives or renewables ROCs. The cost-efficiency of renewable technologies.
- **Renewable Technology I: Generation** - Energy converters: wind; wave; tidal; solar; biomass. Energy and transport. The measurement of energy resources. (Recommended Elective Module)
- **Environmental Processes** - Environmental and ecosystem processes. Energy in the environment: its origins and estimation. Environmental disturbance associated with energy use.
- **Environmental Policy and Risk** - Principles of international law. Property rights and energy resources. Environmental impact assessment, risk assessment methods and techniques. Environmental risk assessment contexts and constraints.
- **Renewable Technology II: Integration** - Technical aspects of generation and integrating renewable energy into distribution networks. Including generation; integration (electricity, heat or fuel networks), distribution and energy use; storage of renewable energy. (Recommended Elective Module).
- **Development Appraisal for Renewable Energy** - Development constraints and opportunities: EIA; capacity studies and the planning system. Valuation of capital assets (discounting, years purchase valuation) and developer's budget. Financial appraisal of renewable projects (payback, ROCE, IRR and NPV).

- **Team development project** - Team project completing the pre-development planning for a hypothetical development. Including resource assessment, site selection, development layout, consents licensing, planning, economic appraisal, development plan; economic social and environmental impact assessment. As well as these there is an optional design project module and a dissertation selected with agreement of supervisor.

As well as these there is an optional Design Project module and a dissertation selected with agreement of supervisor. Exemption assignments are available for certain modules where the student is able to prove existing subject competence. The assignment gives the opportunity for more in depth exploration of a selected aspect of the subject area. The topic for the assignment will be agreed between the student and the module leader.

10.10 Renewable Energy Engineering

http://www.postgraduate.hw.ac.uk/course/242/

Institute of Petroleum Engineering, Heriot-Watt University, Edinburgh, UK, M.Sc.

This course will provide an advanced MSc course in the rapidly expanding area of renewable energy engineering. The course is aimed at students wishing to develop critical understanding of the significant changes afoot in the energy system due to the development and integration of wind, marine, biomass and solar technologies. The course will provide graduates of a calibre capable of developing and implementing creative solutions to the problems encountered in renewable energy capture, conversion, storage and management.

This course is concerned with the concepts, applications, design, development and deployment of renewable energy converters, and energy storage and demand management systems. The aims are to enable the students to:

- develop detailed knowledge and critical understanding of the core skills in renewable energy resources, converters and systems.
- develop and use a significant range of principal and specialist skills, techniques and practices in renewable energy
- be able to apply this knowledge directly to complex applications,
- critically review existing practice and develop original and creative solutions to problems within the domain,
- communicate and work effectively with peers and academic staff in a variety of tasks, demonstrating appropriate levels of autonomy and responsibility, and
- plan and execute a significant project of research, investigation or development in a specialist area within the renewable energy arena, demonstrating extensive, detailed and critical understanding of that specialism.

Core Modules

- Foundations of Energy
- Economics of Renewable Energy
- Renewable Energy Technologies
- Advanced Renewable Energy Engineering
- Environmental Impact Assessment
- Demand Management and Energy Storage
- Critical Analysis and Research Preparation
- Masters Dissertation

Optional Modules
- Electrical Power Systems
- Heat Transfers and Heat Exchangers
- Computational Fluid Dynamics with Heat Transfer

Duration: 12 Months

Annual Tuition Fee: € 4,190.00
€ 13,220.00 (non-EEA)

10.11 Sustainable Development, Energy and Management

http://www.salford.ac.uk/course-finder/course/1382

School of Computing, Science & Engineering, University of Salford, Salford, UK, M.Sc.

The engineering units cover appropriate materials, energy utilisation and theory of renewable energy technologies, power generation, solar thermal and photovoltaic energy, wind energy and water power. Coursework includes units on management techniques such as logistics and operations management, crucial to the successful implementation of new technologies.

Modules include:
- Sustainability
- Renewable Energy
- Solar, Wind and Water Power
- Operational Techniques and Management
- Energy Utilisation
- Quality and Logistics
- Integrated Transport Planning
- Appropriate and New Material Technology.

The dissertation allows students to pursue their own interests. Many projects have been carried out in industry and in energy-related community projects. Many students continue their dissertation work into PhD studies after completion of an MSc.

Duration 12 Months

11 FRANCE

http://intl.ensm-douai.fr/article.php3?id_article=18&lang=en&lang=en

Ecole des Mines de Douai

The **professional master "Clean Energy from Waste and Biomass",** taught in partnership with the "Ecole des Mines d'Albi" highlights the production processes for energy using biomass and waste. That program is particularly dedicated to foreign students willing to perform in a solid scientific program including a supervised work experience program in a French company.

12 IRELAND

12.1 Master Siencec in Energy Management

http://www.dit.ie/study/postgraduate/browse/programmes/title,610,en.html

Dublin Institute of Technology, Dublin, Ireland

The programme has been planned in response to a need in Industry for a master`s degree programme that integrates energy, environmental issues and management. The programme will enhance the present and future effectiveness of managers, engineers and scientists by providing an opportunity to study the theory and practice of current developments, laws, standards, technologies, management, economics and finance, associated with European energy and environmental issues. Graduates from the programme will be effective managers of environmental technology with an in-depth awareness of resource management under financial and environmental constraints. The programme is designed primarily for engineers, but will also be of interest to scientists, managers and multi-discipline professionals such as environment health officers, architects and planning officers.

The programme is delivered through lectures, assignments and tutorials and consists of three stages. Stage 1 comprises of 6 compulsory core modules. Stage 2 comprises of 6 optional modules. Stage 3 comprises of a project/ dissertation. On average it takes two years part-time at three evenings per week to complete stages 1 and 2. Stage 3 will be either an industrial or College based project normally completed over a period of one year. Project supervision will be provided by DIT. Sample of course modules currently on offer include:

Stage 1:
Business (Organisational Behaviour)
Law (Business Law)
Financial Decision Making
Energy Supply
Energy Conversion and Use
Energy Management Principles and Practice

Stage 2: Optional (choose 6)
Business (strategic Management)
Law (Energy & Environment Law and Policy)
Financial Management
Wind Energy for Electricity Supply
Advanced Energy Systems
Sustainable Building Design
Power System Analysis
Embedded Generation
Renewable Energy Technologies
Biomass Technology / Bio fuels for Transport
Energy Control Systems
Low Energy Lighting Design
Stage 3:
Dissertation and Research Methodologies

12.2 Masters in Sustainable Energy

http://www.ucc.ie/en/study/postgrad/what/sefs/masters/sustainable/

University College Cork, Ireland

UCC have developed a Masters in Engineering Science in Sustainable Energy, in recognition of the growing international market for sustainable energy systems and the shortage of qualified engineers. This programme is open to Engineering graduates of all disciplines with an 8 month programme option leading to a Postgraduate Diploma in Sustainable Energy. The course is one year (12 months) full-time and two years part-time.

The focus in this programme is on equipping the students with the information base and skill set to actively participate in this growing global market where energy/environment policy and technological innovation meet. The students will choose 10 taught modules (of the 11 shown in the table) and carry out a preliminary research project within the first 8 months from October. Those who obtain at least 60% in both coursework and research are then eligible to undertake a minor thesis (4 months) over the summer, leading to the award of the Masters degree.

Modules include:
- Sustainable Energy
- Energy in Buildings
- Wind Energy
- Biomass Energy
- Solar and Geothermal Energy
- Electro-technology and Control
- Energy Systems in Buildings
- Renewable Energy Integration
- Hydro and Ocean Energy
- Energy Systems Modelling
- Environmental Impacts, Economics and Project Financing

13 ESTONIA

13.1 Materials and processes of sustainable energetic

http://www.ip.ttu.ee/index.php?lang=est&main_id=234
http://www.sustainableenergetics.eu/

Faculty of chemical and materials technology, Tallinn University of technology

Programme Description
Materials science and technology is traditionally strongly based on hemical science and education. In line with the development of new high tech materials, technologies and processes, their properties are studied at the Faculty of Chemical and Materials Technology. As a result of successful research in the field of new electronic materials European and Estonian Centre of Excellence for the study of the materials for solar energy was nominated in our Faculty. Also extensive cooperation with Tartu University, European universities and industry are conducted which gives for students excellent possibilities for practicing and working abroad.

STRUCTURE OF THE CURRICULUM
- General studies 10 Credit Points (CP)
- Basic studies 10 CP
- Core studies 10 CP
- Special studies 50 CP
- Free choice courses 10 CP
- raduation thesis 30 CP

TOTAL 80 CP (120 ECTS)

GENERAL STUDIES
- Law 3 CP
- English for Science 3 CP
- Social Skills and Ethics 4 CP

BASIC STUDIES
- Inroduction to Studies 3 CP
- Chemistry and Physics for Engineers 7 CP
- or Engineering for Natural Scientist 7 CP

CORE STUDIES
- Fundamentals of Sustainable Energy Engineering 4 CP
- Research work and Innovation 3 CP
- Project Management and Quality Control 3 CP

SPECIAL STUDIES

Module 1
- Applied Energy Engineering 3 CP
- Thermodynamics 4 CP
- Fundamentals of Materials Science 4 CP
- Energy from Agriculture 4 CP

Module 2: Research Project 15 CP

Module 3: Materials
- Physico-chemical Properties of Materials 5 CP
- Materials Research and Characterization 5 CP
- Materials Technology 5 CP
- Applications of Materials 5 CP
- or Processes
- Energy Saving and Conversion 5 CP
- Energy Transport 5 CP
- Energy Storage 5 CP
- Energy Management and Planning 5 CP

14 DENMARK

14.1 Master of Science in Engineering (Sustainable Energy) – study line in biofuels

http://www.risoe.dk/Education/MSC/biofuel.aspx
www.dtu.dk

Technical University of Denmark

Of vital interest to the future of society is the production of cheap renewable fuels via biotech processes. A variety of crops as well as waste materials can be employed as the substrates for such processes, however these must first be converted into substrates that can be consumed by the microbial cells that produce the fuels in subsequent fermentation processes. In this study line you will gain competencies in a variety of fields such as enzymatic hydrolysis of raw materials and fermentation technologies.

Prerequisites
It is essential that students have completed the following courses prior to admission (or their equivalent), as these courses constitute a major part of the academic foundation for the study. Should students not have completed all of these courses, up to 20 points can be taken during the masters education and subtracted from the requirement for elective courses.
27022 Biochemistry 5 points
27025 Molecular Microbiology 10 points
27032 Fermentation Technology 10 points
It is recommended that the following courses have also been completed:
27023 Experimental Biochemistry 5 points
27611 Introduction to Bioinformatics 5 points

In addition, BSc engineers specialising in Chemistry or Chemistry and Biotechnology may be admitted provided that at least 10 credit points from among the following courses form part of their programme:
01035 Advanced Engineering Mathematics 25 points
02405 Probability theory 5 points
02413 Statistical Quality Control 5 points
02601 Introduction to Numerical Algorithms 5 points
02701 Introduction to Operations Research 5 points
27022 Biochemistry 5 points
27023 Experimental Biochemistry 5 points
27032 Fermentation Technology 10 points

Biochemistry and Molecular Microbiology are strongly recommended by the Programme coordinator of the MSc degree programme in Sustainable Energy.
Technical science BScs and BSc engineers from other academic institutions may qualify for admission if the components of their qualifications are equivalent to those described above.

Programme Provisions
To earn an MSc degree in Sustainable Energy with Biofuels studyline, students must fulfil the following requirements:

- Have passed General Competence courses adding up to at least 30 ECTS points
- Have passed Technological Specialisation courses adding up to at least 30 ECTS points

- Have carried out a Master thesis project of at least 30 ECTS points within the scope of the general programme
- Have passed a sufficient number of Elective courses to bring the total number of ECTS points for the entire course of study to 120

List of courses

General competences (30 ECTS): (Compulsory)
45003 Energy resources, markets and policies
45002 Modelling and analysis of sustainable energy systems
45500 Sustainability assessment of energy conversion and use
Technological Specialization Courses (40 ECTS)
Compulsory TS course
45004 System assessment of energy technologies (E3B, 5 ECTS)

2. Elective TS-courses: (35)
27405 Metabolic Engineering and Functional Genomics 10 points
27508 Enzyme Discovery 5 points
27041 Introduction to systems biology 5 points
27411 Biological data analysis and chemometrics 5 points
45501 Production of biofuels 10 points
45502 Biorefinery 5 points

Elective Courses
10 ECTS must be taken either from the below list of courses or from excess courses from the group Elective TS-courses. The remaining 10 ECTS can be used freely for any of the DTU advanced courses.
27231 Molecular Cell Biology 10 points
27409 Industrial Mycology 5 points
27412 Microbial Chemistry 5 points
27413 Experimental Applied Biodiversity 5 points
28233 Recovery and purification of biological products 5 points
28246 Applied enzyme technology and kinetics 5 points
28247 Advanced enzyme technology 5 points
28345 Bio-reaction engineering 5 points
28350 Process Design: Principles and Methods 10 points

Masters Thesis (30 ECTS points)
The master thesis will typically comprise a whole semester of research work involving experiments and/or modelling of eg. enzymatic processes, fermentation of substrates to e.g. ethanol, design of improved enzymes, design of improved microbial strains, process integration or control, etc. The research project will usually be carried out either at BioCentrum-DTU or Risø DTU.

Admission, tuition and so on…
http://www.dtu.dk/English/education/Prospective%20MSc%20Student.aspx

15 UNIVERSITIES OF APPLIED SCIENCES

15.1 Master of Renewable Energies (other degree)

Wildau institute of technology (WIT), University of applied Sciences Wildau, Germany

The programme is designed for students with a Bachelor's or Diploma degree in engineering or science with professional experience and management potential. Successful candidates may look forward to worldwide career perspectives in the field of electricity, equipment manufacturing, consulting or with a regulatory government body

The programme covers the following areas of competence:

Energy Technology
- Energy Technology
- Equations of Change and Transport
- Plant Design
- Fuel Process Technology
- Technical Control Systems
- Energy Engines and Fuel Cells
- Computational Fluid Dynamics
- Energetic Logistics
- Renewable Fuels
- Power Generation
- Grid Distribution

Advanced Engineering Skills
- Rational Thermodynamics
- Advanced Mathematics
- Chemistry
- Microbiology
- Design

Management and Social Skills
- Managerial Accounting
- Corporate Finance
- Leadership and Motivation
- Energy Economics and Policy
- Cross Cultural Communication

Target Group

The programme is designed for students with a Bachelor's or Diploma degree in engineering or science with some professional experience and proven management potential and ambition. Successful candidates may look forward to worldwide career perspectives in the field of electricity, equipment manufacturing, consulting or with a regulatory government body.

15.2 Energy conversion and management (ECM)

Graduate School Offenburg, Germany, University of Applied Sciences Offenburg

The arising technical and economical challenges in a liberalized energy market demand a new kind of engineer. The ability of operating globally and solving technical and economical problems in energy contracting, sales and acqisiton or energy distriubtion is the major objective.

The Programme is especially tailored as second degree for Bachelors in a technical domain or science who intend to proceed with a MSc Programme in an interdisciplinary field, combining technical and specialised aspects of energy related buisness administration and management. The students will accomplish the master degree as a modern engineer which comprehends the technical as well as the management part of the energy market.

Other special features:

- Exchange programmes with several foreign partner universities
- Well equipped laboratories, including steam power plant, gas turbine, co-generation plant as well as biomass gasification plant. The "Energy Island" is an installation where students can be trained in technical and economical tasks.
- Highly qualified lecturers with industrial experience
- Field trips specifically corresponding to carefully selected companies of the energy market

The programme is offered by the University of Applied Sciences Offenburg, a German institution of higher education which is known for its application-oriented teaching, cutting-edge research, small study groups and its beautiful location in the Black Forest. The University's Graduate school coordinates the programme and provides a wide range of special services to foreign students that enable them to feel comfortable at the university and at home.

The first year consists of lectures in core subjects and elective courses. Attendance of core lecutres is require and students under go continous assessment. The modular structure of the programme allows students to choose among various course modules which lead to different individual specialization, such as Installations and Design, Management and Markets, Automotive Energy Engineering or Energy and Environment.

All course work and exams during the first semester are in English, during the second mostly in German. Language classes accompany the curriculum. The third semester is dedicated to the Master's thesis. Scientific work for the thesis may be conduted either at the University of Offenburg or in industry. Technical and economic projects are nomally perfomed in one of the following fields: turbines, co-generation of electricity and heat, regenerative/sustainable energy sources, energy transport, distribution and storage, emission control and mesaurement techniques, exhaust gas cleaning.

Jyväskylän yliopiston biologian laitoksen tiedonantoja -sarjassa ilmestyneet julkaisut

1 SIENITALOUSSEMINAARI 7.–8.4.1975.

2 RAATIKAINEN M, SAARI V, KANKAALA P, KARILA V, KOVANEN J ja PULKKINEN E 1975: Korospohjan pumppuvoimalaitosalueen kasvisto ja eläimistö.

3 KEVOJÄRVEN JA SEN LÄHILAMPIEN HYDROBIOLOGIASTA. Hydrobiologian laudaturkurssi Utsjoen Kevolla 15.–22.7.1974. 1976.

4 ELORANTA V 1976: Levätestit selluloosateollisuuden prosessi- ja pääkanaalijätevesien sekä eräiden limantorjunta-aineiden vaikutusten selvittämisessä.

5 SAARI V ja OHENOJA E 1976: Korpilahden Vaarunvuorten suursienistä.

6 JUSSILAINEN M ja ELORANTA P 1976: llmakuviin perustuva tutkimus Konneveden ja Peurunkajärven vesikasvillisuudesta.

7 VESAKONTORJUNTA-AINESYMPOSIUMI. 1977.

8 PALOKANGAS R 1977: Studies on avian thermoregulation with special reference to heat production in cold and seasonal acclimatization.

9 SAARI V 1978: Korpilahden Vaarunvuorten lehtisammalkasvistosta.

10 ELORANTA P ja ELORANTA A 1978: Tutkimus kalaston rakenteesta ja kalojen kasvusta Kuusvedessä, Ahvenisessa ja Leivonvedessä (Laukaa).

11 HUHTA V, SUNDMAN V, IKONEN E, SIVELÄ S, WARTIOVAARA T ja VILKAMAA P 1978: Jäteliete-kuorirouheseosten maatumisen biologia.

12 KOSKELA H 1979: Structure and dynamics of the beetle community inhabiting cow dung.

13 VIHKO V 1979: Response of the lysosomal system of skeletal muscle to exercise.

14 NORD-EUROPEISKA OGRÄSSYMPOSIET I DICKURSBY, FINLAND DEN 7.–10.9.1976 DEL I. 1979.

15 NORD-EUROPEISKA OGRÄSSYMPOSIET I DICKURSBY, FINLAND DEN 7.–10.9.1976 DEL II. 1979.

16 NURMELA P-L 1979: Jämsän ympäristönhoitotutkimus.

17 RÄSÄNEN L 1979: Elaboration of leukocyte inhibitory factor (LIF) by human peripheral blood lymphocytes and cellular collaboration in LIF production.

18 SIHVONEN H 1979: Jämsänkosken kunnan ympäristönhoitosuunnitelma.

19 NCE-SYMPOSIUM ''Ecology and fishery biology of small forest lakes" Lammi 15.–17.11.1978.

20 I. LUONNONTIETEELLISTEN MUSEOIDEN IV VALTAKUNNALLISET NEUVOTTELUPÄIVÄT 2.4.–3.4.1979 JYVÄSKYLÄSSÄ. II. YLIOPISTOJEN PUUTARHOJEN II VALTAKUNNALLISET NEUVOTTELUPÄIVÄT 2.4.–3.4.1979 JYVÄSKYLÄSSÄ.

21 RAATIKAINEN T 1979: Jyväskylän yliopiston viheraluepuutarhan esiselvitys.

22 FINEM-79. SUOMALAISTEN ELEKTRONIMIKROSKOPISTIEN SYMPOSIUMI 27.-28.9.1979 JYVÄSKYLÄSSÄ.

23 HIRSIMÄKI P 1980: Studies on vinblastine-induced autophagosytosis in mouse liver.

24 KOLEHMAINEN K 1980: Saarijärvi-Kalmari. Kalmarin kyläkuva, suunnitelmia ja toimenpide-ehdotuksia.

25 JYVÄSKYLÄN YLIOPISTON BIOLOGIAN LAITOS 10 VUOTTA.

26 SELIN P, KOKKO H ja HAKKARI L 1981: Sulfiittiselluteollisuuden jätevesien likaaman Lievestuoreenjärven pelagiaalin ravintoketjututkimus.

27 VIHKO V ja SALMINEN A 1981: Raajalihaksen lysosomaalisen järjestelmän mukautuminen fyysiseen kuormitukseen. Loppuraportti Valtion liikuntatieteellisen toimikunnan rahoittamasta tutkimuksesta vuosina 1978-1980.

28 KÄPYLÄ M, TÖNNES P ja VEIJOLA H 1981: Siitepölyn, sieni-itiöiden ja puupölyn esiintyminen Jyväskylän kaupunki-ilmassa.

29 Saarijärven Pyhä-Häkin kansallispuiston ja sen lähiympäristön metsäjärvien veden laatu, klorofyllipitoisuus, eläinplankton, pohjaeläimistö sekä vesihyönteis- ja vesipunkkilajisto. 1982.

30 ELORANTA A 1982: Tutkimuksia eräiden kivikkorantojen kalalajien biologiasta. I.

31 LAHTI T 1983: Ruoveden Siikanevan linnusto.

32 RAATIKAINEN M 1983: Kasvitieteellinen julkaisutoiminta Jyväskylän yliopistossa. RAATIKAINEN, M. ja NIEMELÄ, M. 1983: Mustikan poimintatarkkuuden määrittäminen. RAATIKAINEN M, RAATIKAINEN T ja SAARI V 1983: Saarijärven Voudinnemen kasvilajisto.

33 KONNEVESISYMPOSIO. I. 7.–8.4.1983.

34 KONNEVESISYMPOSIO. II. 7.–8.4.1983.

35 MARTTINEN KMJ 1983: Tutkimus Kynsiveden syvänteiden kalastosta touko-lokakuussa 1980.

36 HUHTA V, HYVÖNEN R, KOSKENNIEMI A, VILKAMAA P, KAASALAINEN P ja SULANDER M 1984: Metsänlannoituksen ja pH:n vaikutus maaperäeläimistöön.

37 LUOTOLA M 1984: Behaviour and effects of some xenobiotics as studied in laboratory model ecosystems.

38 JÄRVIEN JA JOKIEN POHJAELÄINTUTKIJOIDEN KOKOUS 13.–15.10.1983.

39 SAARI V, RAATIKAINEN T ja VÄLIVAARA R 1984: Korpilahden ja Muuramen uhanalaiset kasvit.

40 V EKOLOGIPÄIVÄT JYVÄSKYLÄSSÄ 12.–13.4.1984.

41 SALONEN HW 1985: Salamajärven kansallispuistossa sijaitsevan Koirajoen rantojen kasvillisuus ja kasvisto.

42 SALONEN V ja SAARI V 1985: Korpilahden Ristisuon kasvisto, kasvillisuus ja suojelu.

43 ELORANTA A 1985: Tutkimuksia eräiden kivikkorantojen kalalajien biologiasta. II.

44 KALLIO-MANNILA K, RAATIKAINEN M ja RAATIKAINEN T 1985: Kevätviljapeltojen rikkaruoholajiston muutoksista 1960-luvulta 1980-luvulle.

45 Vlll NORDIC MYCOLOGICAL CONGRESS 18.–22.8.1986.

46 MIKOLA L 1986: Cereal carboxypeptidases: occurrence, properties and possible functions.

47 SUNDELL P ja SAARI V 1986: Jyväskylän maalaiskunnan ja Laukaan uhanalaiset kasvit.

48 SIPPONEN M 1987: Keskisuomalaisten kotitarve- ja virkistyskalastuksesta ja sen arvosta v. 1981 erityisesti vesioikeudellisen intressivertailun kannalta.

49 HIRSIMÄKI P ja REUNANEN H 1987: Autofagosytoosin mekanismi ja säätely.

50 RAATIKAINEN T ja RAATIKAINEN M 1988: Pihtiputaan uhanalaiset putkilokasvit ja niiden suojelu.

51 ELORANTA P 1988: Etelä- ja Keski-Suomen kansallispuistojen järvien kasviplanktonista heinäkuussa 1987.

52 HALTTUNEN-KEYRILÄINEN L 1988: Ympäristöviranomaisten koulutus- ja pätevyysvaatimuksista kunnissa. Kuntakyselyn tulokset.

53 REUNANEN H 1989: Ultrastructural studies on cellular autophagocytosis in vivo and in vitro.

54 HARVISALO S ja RAATIKAINEN T 1989: Kinnulan, Kivijärven ja Kyyjärven uhanalaiset putkilokasvit.

55 RAATIKAINEN M, IHANAINEN E ja RAATIKAINEN T 1989: Viitasaaren uhanalaiset putkilokasvit ja niiden suojelu.

56 HUHTA V, HAIMI J. SETÄLÄ H, BOUCELHAM M, MARTIKAINEN E ja TYYNISMAA M 1989: Maaperäeläinten merkitys tuoreen kangasmetsän hajotuksessa, ravinnekierrossa ja maannostumisessa.

57 PEITSENHEIMO-AARNIO S ja RAATIKAINEN T 1989: Joutsan, Leivonmäen ja Luhangan uhanalaiset putkilokasvit ja niiden suojelu.

58 EISTO A-K ja RAATIKAINEN T 1989: Hankasalmen ja Toivakan uhanalaiset putkilokasvit.

59 EKOTOKSIKOLOGIAN SEMINAARI. Jyväskylän yliopisto 27.–28.11.1990.

60 RAATIKAINEN M 1990: Putkilokasvilajien yleisyyden muutokset 1900-luvun Pihtiputaalla.

61 USTINOV A ja RAATIKAINEN M 1991: Lestijärven ja Toholammin uhanalaiset putkilokasvit.

62 LIIKUNTA JA LUONTO -SEMINAARI. LIKES, Jyväskylän yliopisto, Keski-Suomen liitto, Jyväskylän latu ry. 21.5.1991.

63 HAMARUS A, HELENIUS M ja SAARI V 1991: Jyväskylän uhanalaiset kasvit.

64 CONFERENCE ON THE ECOPHYSIOLOGY OF THE LIFE CYCLES OF FISH AND THEIR PARASITES. Konnevesi Research Station 10.3.–11.3.1992.

65 HALLMAN J ja RAATIKAINEN M 1992: Halsuan ja Perhon uhanalaiset putkilokasvit.

66 ERVI LO ja RAATIKAINEN M 1993: Multian putkilokasvit.

67 RAATIKAINEN M ja SAARI V 1994: Viitasaaren seutukunnan lehtisammalet.

68 MARJOMÄKI T ja HUOLILA M 1994: Puulaveden kalatutkimuksia I.

69 HÄNNINEN K, KOIVULA N, MIIKKI V ja TOLVANEN O 1999: Erilliskerätyn biojätteen aumakompostointi Mustankorkealla Jyväskylässä.

70 HÄNNINEN K, ASIKAINEN A, YLI-KETURI N, RUOKOJÄRVI P, AATAMILA M, HALONEN I, TUPPURAINEN K, VESTERINEN R, MIKKELSON P ja RUUSKANEN J 2000: Nestemäisen inhibiittoriyhdisteen käyttö todellisen yhdyskuntajätteen poltossa muodostuvien kloorattujen PCDD/F-yhdisteiden vähentämiseen.

71 HÄNNINEN K, YLI-KETURI N, MIKKELSON P, PENTTILÄ H, VESTERINEN R, PAAKKINEN K, HALONEN I, ASIKAINEN A, RUOKOJÄRVI P, TUPPURAINEN K ja RUUSKANEN J 2000: Kemiallis-fysikaalisten tekijöiden vaikutus PCDD/F-yhdisteiden *de novo* -muodostumiseen ja sen ehkäisemiseen jätteenpoltossa.

72 HÄNNINEN K, AILUNKA H, KOTIMÄKI I, MAIJALA V, LAMBACKA H, HEIMONEN R ja KUOSKU V 2001: Poron teurasjätteen kompostointi ja kasvatuskokeet kompostilla.

73 HÄNNINEN K, KOIVULA N, MIIKKI V, URPILAINEN S and RÄIKKÖNEN T 2001: Source separation and composting of biowaste with a view to recycling of the end product.

74 LAMPINEN A 2001: Jyväskylän yliopiston uusiutuvan energian koulutus- ja tutkimusohjelma – Tausta ja toimintaympäristö.

75 LAMPINEN A 2001: Co-operation possibilities on renewable energy between Finland and India.

76 TOLVANEN O ja HÄNNINEN K 2001: Uusinta teknologiaa hyödyntävien jätteenkäsittelylaitosten työhygienia v. 1998-2001: bioaerosoli- ja melumittaukset. Suomen Akatemian projekti n:o 42503/1998. Loppuraportti.

77 VIILOS P, IMPPOLA U, VEIJANEN A ja HÄNNINEN K 2002: Uusinta teknologiaa hyödyntävien jätteenkäsittelylaitosten työhygienia v. 1998-2001: haihtuvat, haisevat yhdisteet. Suomen Akatemian projekti n:o 42503/1998. Loppuraportti.

78 RAHEEM K, HÄNNINEN K and AKINROYE K (eds.) 2002: West Africa clean studies. Proceedings of the 1st and 2nd international conferences on waste management. Lagos, Nigeria, 2000 and 2001.

79 HÄNNINEN K ja MIIKKI V (toim.) 2003: Biojätteiden paineistettu anaerobinen biokonversio.

80 HUTTUNEN S 2004: Paikallista kestävää energiaa – Uusiutuvan energian mahdollisuudet maatiloilla.

81 HUTTUNEN S and LAMPINEN A 2005: Bioenergy technology evaluation and potential in Costa Rica.

82 RONKAINEN O, KOSKINEN P, LEHTOMÄKI A, LAMPINEN A, TOIVAINEN K, KAKSONEN A, PUHAKKA J ja RINTALA J 2005: Biologinen vedyntuotanto pimeäfermentaatioprosessilla.

83 KUMPULAINEN T 2005: Jyväskylän kaupungin perhoslajisto vuosina 1995 - 2005: I - päiväperhoset ja muu huomionarvoinen perhoslajisto.

84 LAMPINEN A ja JOKINEN E 2006: Suomen maatilojen energiantuotantopotentiaalit – Ekologinen perspektiivi.

85 LEHTOMÄKI A, PAAVOLA T, RINTALA J ja LUOSTARINEN S 2007: Biokaasusta energiaa maatalouteen – Raaka-aineet, teknologiat ja lopputuotteet.

86 HÄNNINEN K 2008: Ympäristökemian perusteet (2. painos 2009).

87 HÄNNINEN K 2009: Jätteiden käsittely ja kierrätys Suomessa

88 HÄNNINEN K JA HIMANEN M 2010: Ympäristömittausten laboratoriotyötavat

89 HÄNNINEN K 2010: Kemiallinen ympäristöanalytiikka

90 TÄHTI H ja RINTALA J 2010: Biometaanin ja –vedyn tuotantopotentiaali Suomessa

91 MÄKÄLÄINEN E JA WIHERSAARI M 2011: Kestävän bioenergiatulevaisuuden rakentaminen: Verkko-opetuksen kehittäminen

DEPARTMENT OF BIOLOGICAL AND ENVIRONMENTAL SCIENCE, UNIVERSITY OF JYVÄSKYLÄ, FINLAND

ISBN 978-951-39-4222-9 (nid.)
ISBN 978-951-39-4223-6 (verkkoj.)