Barents Environmental Engineering

Master's Degree Programme (BCBU)
in Environmental Engineering

BEE

STUDY GUIDE 2011 – 2013

BEE Study guides 2009-2013

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University of Oulu, Finland

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1 BEE, THE MASTER'S DEGREE PROGRAMME (BCBU) IN ENVIRONMENTAL ENGINEERING

The Master's Degree Programme Barents Environmental Engineering (BEE), officially called *Master's Degree Programme (BCBU) in Environmental Engineering*, is a two-year programme of 120 ECTS in the University of Oulu, Finland. Graduating BEE students will be awarded a degree of Master of Science in Technology. BEE is one of the Barents Cross Border University (BCBU) Master's Degree Programmes, and was originally developed in international cooperation with the Barents Region universities in Finland, Norway, Sweden, and Russia.

The BEE programme is based on environmental, process, and civil engineering. BEE curriculum is multidisciplinary, including subjects ranging from the before-mentioned engineering sciences to ethics and legislation, economics and ecology. The programme takes two years with 120 ECTS of studies, and can include an exchange period in one of the participating BCBU universities.

1.1 Orientations or study options in BEE

Currently the main responsibility for the delivery of the BEE programme is carried out by the Department of Process and Environmental Engineering at the Faculty of Technology, University of Oulu with two ongoing BEE orientations (Clean Production, Water and Environment), and one orientation, Sustainable Energy, run along these. Further, in two Russian universities, Northern (Arctic) Federal University (NArFU), and Murmansk State Technical University, there are ongoing orientations related to the BCBU/BEE programme: Industrial Ecology and Rational Use of Natural Resources, and Integrated Use of Water Resources respectively.

1.1.1 Clean Production / University of Oulu

The Clean Production (CP) orientation includes studies on reducing the environmental load of process industry, and provides knowledge on how to manage environmental issues within the industry by application of proper methods, tools and technologies. The CP orientation was started in September 2009 at the University of Oulu, Finland.

1.1.2 Water and Environment / University of Oulu

The Water and Environment (WE) orientation includes studies on protection and restoration of natural environment, as well as water and soil pollution, water and waste water treatment, and waste technology. The WE orientation was started in September 2009 at the University of Oulu, Finland.

1.1.3 Sustainable Energy / University of Oulu & Narvik University College

Even though the Sustainable Energy (SE) orientation is not actually a true BEE orientation, but a one study option in the two national Master's Degree programmes of the Department and Environmental Engineering, it is described here.

The Sustainable Energy (SE) orientation answers the need to find green energy solutions especially for the Barents area environmental conditions. Strong focus is set on hydro-, wind-, solar- and bioenergy technologies, as well as energy efficiency issues in production, distribution and end use. Orientation was started in September 2010 at the University of Oulu, Finland, as part of the two national Master's programmes of the Department and Environmental Engineering, and contains a compulsory one semester long exchange period at the Narvik University College, Norway.

1.1.4 Other orientations / Russia

Industrial Ecology and Rational Use of Natural Resources (Environmental technology and management) orientation includes implementation of the green chemistry principles in industry for treating environmental problems, control and assessment and control of environmental state, and environmental management. Orientation was started in September 2010 at The Northern (Arctic) Federal University (NArFU), Russia.

Integrated Use of Water Resources orientation provides knowledge on multi-purpose use of water resources, and proper tools and technologies for water and wastewater treatment for industry and municipalities. Orientation was started in September 2009 at Murmansk State Technical University, Russia.

1.2 Student exchange

Barents Masters Programme in Environmental Engineering can contain an exchange period at some of the BCBU/BEE partner universities. In the Clean Production and Water and Environment orientations courses completed during the exchange period can be included in the curricula's supplementary module. These courses must be agreed in advance with the BEE Student Advisor. In the Sustainable Energy orientation the students from the University of Oulu will take the exchange period at the Narvik University College in Norway, where the second year autumn of the SE orientation is implemented, and possibly also the master's thesis phase of the studies.

2 INTRODUCTION TO THE BARENTS CROSS BORDER UNIVERSITY

The Barents Cross Border University, BCBU, is a project aiming to develop and jointly organise international, multidisciplinary Master's Degree Programmes. The Master's Degree programmes (currently five programmes) within BCBU follow the principles of the Bologna process and the teaching is given in English in all. Later the cooperation will also cover doctoral education in the same fields. The BCBU project is based on the co-operation between universities in Northern Finland and Scandinavia and Northwest Russia. This co-operation was founded on 2006 (intention agreement undersigned on March 2007) in the mutual interests of the partner universities, as well as in the principles and aims of the partnership programmes and the EU Northern Dimension Policy[1].

Within BCBU, there are two full partner universities in Finland and eight full or associate partners from Russia and five partners from other countries. The partners collaborate in different combinations in the five BCBU Master's Degree Programmes. The BCBU full partners from Finland are University of Oulu and University of Lapland in Rovaniemi. From Russia, the partners are Northern (Arctic) Federal University, Pomor State University and Northern State Medical University in Arkhangelsk; Petrozavodsk State University and the Karelian State Pedagogical University in Petrozavodsk; and Murmansk State Technical University, Murmansk State Pedagogical University, and Murmansk Humanities Institute in Murmansk. The BCBU associate partners are Narvik University College in Norway, Luleå University of Technology in Sweden, the University of the Southern Denmark in Denmark, the Centre for Health Education in Greenland, and University of Manitoba in Canada.

The BCBU partners collaborate together to provide currently five two-year cross border Master's Degree programmes, on the fields of social work, environmental engineering, information and communication technology, circumpolar health and well-being, and law. Programmes *Environmental Engineering (BEE), Information Systems (GS3D)*, and *Circumpolar Health and Wellbeing (MCH)* are coordinated by the University of Oulu, and *Comparative Social Work*

[1] EU Northern Dimension Policy, see: http://ec.europa.eu/external_relations/north_dim/index_en.htm

(CSW) and *Law (LAW)* are coordinated by the University of Lapland. The combination of the partner universities in each programme is based on the former cooperation and the expertise in special branches of the participating universities. The study programmes are in the central fields of the EU Northern Dimensions priorities and the language of study in all programmes is English.

Further information about Barents Cross Border University project is available at the BCBU home page http://bcbu.oulu.fi and about the respective Master's programmes at:

- Barents Environmental Engineering (BEE)[2] http://bee.oulu.fi
- Information Systems (GS3D) http://gs3d.oulu.fi/
- Circumpolar Health & Well-being (MCH) http://arctichealth.oulu.fi/suomi/maisterikoulu.html
- Comparative Social Work (CSW) http://www.ulapland.fi/CSW
- BCBU Law (LAW) http://bcbu.oulu.fi/R2011Oulu/LAW_2011.pdf

2.1 General information on the main BCBU/BEE partner universities

Currently six full or associate partners collaborate within the BCBU/BEE programme, and two universities are co-operating in the BEE programme outside the BCBU project.

In the next paragraphs, information is given of the next BCBU/BEE partners and co-operators: University of Oulu in Finland, Narvik University College in Norway, Luleå University of Technology in Sweden, and Northern (Arctic) Federal University, Pomor State University, Murmansk State Technical University, and Petrozavodsk State University in Russia.

2.1.1 University of Oulu

University of Oulu (UO), Finland, is a full partner in BCBU/BEE. UO is an international, multi-disciplinary research university, and one of the largest universities in Finland with an exceptionally wide academic base. Its six faculties (Humanities, Education, Economics and Business Administration, Medicine, Science, and Technology) and their departments form a multi-disciplinary academic community that enables diversified studies based on multifaceted research. The fields of information technology, biotechnology, and northern and environmental issues have been defined as the special research focus areas of UO. UO cooperates closely with industry and commerce, and has broad connections with hundreds of international research and educational institutions. The university also provides a high-quality learning environment for both specialists and generalists in its different study programmes. UO offers currently 15 international Master's Degree programmes in addition to the tens of national study programmes (see more information of these at http://www.degree.oulu.fi/ and http://www.oulu.fi/english/studying/A-Z).

Master's Degree programme BEE at UO is especially targeted in the field of northern and environmental issues. Within this UO research focus area, a multi-disciplinary approach is applied on how climate and environmental changes are impacting northern areas. The ultimate aim is to find new, sustainable ways of protecting and using the northern environment and its natural resources. Other BEE related research interests of UO include studying the health, welfare and culture of the people living in the area. UO has a leading role in the *Thule Institute Global Change in the North Research Programme*[3] and in the *Northern Research Platform of the European Research Area*.

In UO, Department of Process and Environmental Engineering (DPEE), in co-operation with Thule Institute, is the responsible organiser of the BEE programme studies. DPEE is an educational and research unit of 1000 students and 220 employees, operating at all of the focus areas of the University of Oulu: biotechnology and molecular medicine, information technology and wireless communication, and northern and environmental issues. The specific strong area of

[2] Officially 'Master's Degree Programme (BCBU) in Environmental Engineering', see http://www.finlex.fi/fi/laki/alkup/2009/20091665

[3] Global Change in the North Research Programme, see: http://thule.oulu.fi/englanti/research/change.html

the department is its teaching which is based on unit process thinking and on firm know-how in natural sciences. Hence, the Finnish Ministry of Education has awarded DPEE as an acknowledgement for its persistent, long-term development work in teaching, the status of National Centre of Excellence in University Education for years 2004-2006, 2007-2009 and 2010-2012.

DPEE carries out high level, techno-scientific research with strong focus on sustainable process, energy and product development. Its research profile is unique in Finland, as it combines process and environmental engineering and automation. The research subjects relate closely to global environmental problems and intend to contribute to Finland's international competitiveness. The Department has excellent reputation with companies, scientific societies and within the university, which is apparent e.g. in external funding.

Thule Institute (see http://thule.oulu.fi/englanti/index.html) and its unit NorTech are the other major contributors to the BEE programme at UO, in addition to DPEE. Thule Institute is a multidisciplinary research centre in the field of environmental and northern issues and natural resources. Thule has four operational units: Centre for Arctic Medicine, NorNet, NorTech Oulu in Oulu, and Oulanka research station in Kuusamo.

The basis of Thule research consists of three multidisciplinary research programmes: *Global Change in the North, Northern Land Use and Land Cover,* as well as *Circumpolar Health and Wellbeing*. These research programmes are implemented jointly with different units of Oulu University (e.g., with DPEE), other universities, research institutes and the business sector. The Thule Institute also plans and promotes basic and post-graduate studies within the area of focus. Thule arranges seminars and courses and provides information on northern and environmental issues.

DPEE offers two study options or orientations within BEE: *Clean Production* (CP) and *Water and Environment* (WE). Orientation CP includes studies on reducing the environmental load of process industry; and provides knowledge on how to manage environmental issues within the industry by application of proper methods, tools and technologies. The WE orientation includes studies on protection and restoration of natural environments, water and soil pollution, water and wastewater treatment, and waste technology. Further DPEE offers orientation *Sustainable Energy* (SE) as a part of the two national Master's Degree programmes (i.e. actually not available in BEE) in cooperation with the Narvik University College, Norway. The SE orientation will answer the need to find green energy solutions for the Barents environmental conditions. Strong focus is set on hydro, wind, and bioenergy technologies, as well as energy efficiency issues in production, distribution and end-use.

University of Oulu main webpage, see www.oulu.fi/english/, and for Department of Process and Environmental Engineering, see http://pyo.oulu.fi/index.php?72 (please note: these pages are also the source of the above mentioned information).

2.1.2 Narvik University College

Narvik University College (NUC), Norway, is participating in the education of the UO/BEE programme within the area of Sustainable Energy. The SE study orientation has started in September 2010 as a part of the two national Master's Degree programmes of the Department of Process and Environmental Engineering, University of Oulu (i.e. SE is not actually available in UO/BEE), and is offered in cooperation with the NUC.

NUC is one of State University Colleges in Norway which offer higher education through various study programmes. NUC was established in 1994 through the merger of Narvik Engineering College, MSc program in Narvik, and Nordland College of Nursing in Narvik.

NUC has approximately 170 employees and about 1700 students, spreading out on a number of different bachelor or master level study programmes, in the fields of engineering, health and nursing, and business management. The strategic plan of NUC emphasizes that research and

development is a necessary and important part of the business, and that education should be research based and interdisciplinary. College has also commissioned research on a number of areas and has a section for external operations. To improve the quality and inspiration to the renewal and further development of international cooperation, NUC is actively developing contacts with educational institutions in other countries and continents. The emphasis is on exchange programs for students and staff.

NUC is organised in four departments, of which the Department of Building, Production and Engineering Design focuses on e.g. renewable energy, energy in buildings, and energy efficiency. NUC is participating in the education of the BEE programme within the area of sustainable energy.

Narvik University College's main webpage, see www.hin.no/eng (please note: these pages are also the source of the above mentioned information).

2.1.3 Luleå University of Technology

The Luleå University of Technology (LTU), Sweden, is planned to later collaborate in Sustainable Energy programme within OU/BEE. LTU conducts education and research within two faculties (Science and Technology; Humanities and Social Sciences) and six departments (Business Administration, Technology and Social Sciences; Arts, Communication and Education; Health Sciences; Civil, Environmental and Natural resources engineering; Computer Science, Electrical and Space Engineering; and Engineering Sciences and Mathematics). Research at LTU comprises 70 research subjects and is characterised by multidisciplinary cooperation between the different research departments and close interaction with trade and industry and society. LTU would participate in education of the OU and NUC within the area of sustainable energy.

Luleå University of Technology's main webpage, see http://www.ltu.se/?l=en (please note: these pages are also the source of the above mentioned information).

2.1.4 Northern (Arctic) Federal University and Pomor State University

Northern (Arctic) Federal University (NArFU), Russia, former Arkhangelsk State Technical University, is a full partner in BCBU/BEE. Currently NArFU is the largest Federal University in the North-West of Russia and one of the leading public educational-and-scientific complexes in the European North of Russia. NArFU has active cooperation with authorities, industrial companies, scientific research, and educational and cultural institutions in the Arkhangelsk region. It is a major educational centre developing active partnership with business and industry. In the near future, Pomor State University, Northern Machinery Higher Technical Institution, Northern State Medical University and the number of technical colleges will join NArFU.

NArFU is based on the deep integration with the institutions of Russian Academy of Sciences through the involvement of the employees of Arkhangelsk scientific centre in the educational and scientific activities of the university. NArFU provides about 50 five-year degree programmes for main industrial branches of the region. NArFU will participate in education of the BCBU/BEE programme by its study option *Industrial Ecology and Rational Use of Natural Resources*, which includes implementation of green chemistry principles in industry for treating environmental problems, control and assessment of environmental state and environmental management.

Northern (Arctic) Federal University's main webpage, see http://narfu.ru/en/ (please note: these pages are also the source of the above mentioned information).

The reorganization of Pomor State University named after M. V. Lomonosov (PSU), Russia, is in progress, and PSU it will be united to NArFU in future. With this merger, PSU will be a full member in BCBU/BEE.

PSU is a big, competitive classical university, research-oriented educational scientific and innovative complex with the whole cycle of education, highly acknowledged in Russia and

abroad. The University implements accredited training of qualified specialists of the international level; it is a multifunctional centre for education, science and culture in North Europe, Russia and in the Arkhangelsk region. PSU has 21 faculties, 66 departments, 27 scientific centres and laboratories; affiliates in Severodvinsk, Naryan-Mar, and Koryazhma. PSU has over 14 000 students, postgraduates, attendees and over 1500 academic staff; 13 campuses and 8 student dormitories. Staff training is implemented in 8 extended speciality groups: physical and mathematical sciences, natural sciences, humanities, social sciences, education and pedagogics, economics and management, information science and computer engineering, and technology of food products and consumer goods. Pomor State University will participate in the education of the BCBU/BEE programme.

Pomor State University's main webpage, see http://www.pomorsu.ru/?page&id=eng (please note: these pages are also the source of the above mentioned information).

2.1.5 Murmansk State Technical University

Murmansk State Technical University (MSTU), Russia, is a full member in BCBU/BEE. MSTU is one of the oldest higher educational establishments on the Kola Peninsula. The history of the University begins in 1950 as the High Marine School (HMS). Then it was made the Russian State Academy of Fishing Fleet and since 1996 it has become the Murmansk State Technical University, the biggest and the most prestigious educational Center in the Far North of Russia.

At present MSTU is the leader on the educational market of the Murmansk region. There are 9 faculties and more then 30 departments that train specialists in 28 fields. The main purpose of the University is to provide well-qualified specialists for all branches of industry with. The total number of students is about 4500 and the teaching Staff is represented by 400. MSTU carries out not only educational activities, but also intensive research work in various fields and scientific.

MSTU is participating in the education of the BCBU/BEE programme by its study orientation *Integrated Use of Water Resources* provides knowledge on multi-purpose use of water resources and proper tools and technologies for water and wastewater treatment for industry and municipalities.

Murmansk State Technical University's main webpage, see http://eng.mstu.edu.ru (please note: these pages are also the source of the above mentioned information).

2.1.6 Petrozavodsk State University

Petrozavodsk State University (PetrSU) is an associate member in BCBU/BEE. The university has 17 faculties: Agriculture, Mining and Geology, History, Forest Engineering, Mathematics, Medicine, Political and Social Sciences, Baltic and Finnish Philology and Culture, Industrial and Civil Engineering, Physical Engineering, Philology, Ecology and Biology, Economics, Law, etc. The university also includes 3 branches, of which two are located in Karelia (Priladozhsky aka Sortavala, and Belomorsk); and Kola branch located in Apatity at the Murmansk region, and other facilities.

Nowadays the teaching staff of PetrSU is more than 1000 people, and more than 18 500 undergraduate and graduate students study there. PetrSU students have an opportunity to obtain Bachelor's, Master's and Specialist's Degrees in almost hundred majors and minors. PetrSU has 35 international agreements in force with foreign institutes of higher education, research organizations and research-and-production companies of Finland, Canada, the USA, the Great Britain, and Italy. Bilateral agreements with foreign partner universities on student exchange of have been supported for more than 15 years, e.g. with the University of Oulu in Finland.

Cross-border cooperation with Finland and countries of the Barents Euro-Arctic Region holds a specific place in the activities of PetrSU. The Russian-Finnish Cross-Border University (CBU, the

southern Cross Border University) project was launched in 2004, and the Russian-Finnish Barents Cross-Border University (BCBU) joint project with universities of Russia and Finland was launched in 2005.

Petrozavodsk State University main webpage, see
http://www.petrsu.ru/Structure/structure_e.html (please note: these pages are also the source of the above mentioned information).

3 INFORMATION ABOUT THE UNIVERSITY OF OULU, FINLAND

3.1 Oulu University Library and other services

The Oulu University Library is divided into many units, of which the most important for BEE students are the course book library Cursus, the science technology library Tellus and the main library Pegasus. All these units of the library are located in the UO Linnanmaa campus, see map http://www.oulu.fi/dokumentit/kartat/Linnanmaa_2011_suomi.pdf.

More specific information about Oulu University Library units, opening hours and services is available at http://www.kirjasto.oulu.fi/index.php?id=509.

The other international students' services are described at http://www.oulu.fi/english/student-services. See also a map of the guidance services in the University of Oulu at http://www.oulu.fi/students/map_of_guidance.pdf.

3.2 Faculty of Technology

The BEE programme is one of the three international Master's Degree programmes (of which only BEE belongs to BCBU) organised at the Faculty of Technology, which is the largest of the six faculties of the University of Oulu. It is divided into seven departments: Departments of Architecture, Electrical Engineering, Computer Science and Engineering, Communications Engineering, Mechanical Engineering, Industrial Engineering and Management, and Department of Process and Environmental Engineering. The last mentioned is responsible for the BEE programme. The Faculty of Technology with its departments is located at the University of Oulu Linnanmaa campus.

The Faculty administration is managed by Dean and two Vice Deans (one for research and one for education) and a Faculty Council and a Committee for Education. Further, the faculty has Administrative Manager and Student Affairs Manager officials.

Degrees that can be awarded in the Faculty of Technology are Bachelor of Science in Technology; and Master of Science in Technology and Master of Science in Architecture; and further Licentiate of Science in Technology; and Doctor of Science in Technology as respective post-graduate degrees.

Faculty home page http://www.ttk.oulu.fi/English/

3.2.1 Faculty office

Location: Linnanmaa Campus, room YT103, entrance R
Telephone: +358 8 553 1011 (university phone centre) or +358 8 553 2001 / +358 8 553 2002
Office hours 9:00-13:00

3.2.2 Faculty personnel

Dean of the Faculty	Professor Mr. Kauko Leiviskä
Vice Dean in Education:	Mrs. Helka-Liisa Hentilä
Administrative Manager:	Mrs. Laila Kuhalampi
Student Affairs Manager:	Mrs. Sirpa Nelo
Training Issues Planning Officer:	Mrs. Simi Outi

3.2.3 Department of Process and Environmental Engineering

The Department of Process and Environmental Engineering (DPEE) carries out high level, techno scientific research and education with a strong focus on sustainable process, energy and product development. The research profile of the DPEE is unique in Finland, as it combines process and environmental engineering and automation. It conducts research and education in engineering sciences, along all of the focus areas of the University: biotechnology and molecular medicine, information technology and wireless communication, and Northern and environmental issues. The research subjects at the DPEE relate closely to global environmental problems and intend to contribute to Finland's international competitiveness.

The specific strong area of DPEE is its teaching, which is based on unit process thinking. As an acknowledgement for its persistent, long-term development work in teaching, the Department of Process and Environmental Engineering has been awarded the status of National Centre of Excellence in University Education for years 2004-2006, 2007-2009 and 2010-2012 by the Finnish Ministry of Education and Culture.

The research and education activities of DPEE are divided into eight laboratories, lead by professors: Bioprocess Engineering (prof. Heikki Ojamo), Chemical Process Engineering (prof. Juha Tanskanen), Control Engineering (prof. Kauko Leiviskä), Fibre and Particle Engineering (prof. Jouko Niinimäki), Mass and Heat Transfer Process, including the Industrial Environmental Engineering unit (prof. Riitta Keiski), Process Metallurgy (prof. Timo Fabritius), System Engineering (prof. Enso Ikonen), and Water Resources and Environmental Engineering (prof. Björn Klöve). In addition, DPEE has administrative and educational offices, and an engineering workshop together with the Department of Mechanical Engineering. For the DPEE laboratories, see http://pyo.oulu.fi/index.php?62.

DPEE is administrated by Head of the Department and Vice Head of the Department and a Steering Group. Further, the department has office personnel for the implementation of the DPEE affairs. DPEE also has a Study Programme Committee, responsible for development of the DPEE education. There is also a workgroup Pakki for handling student feedback on the department education, studies and courses. PhD-level studies[4] at DPEE are handled in development group Jopokki and by a PhD Studies Coordinator (Dr. Mika Huuhtanen), and research respectively in the research enhancement group TETR.

The Department of Process and Environmental Engineering with its laboratories are located at the University of Oulu Linnanmaa campus.

DPEE webpage: http://pyo.oulu.fi/index.php?id=1&lang_id=1.

3.2.4 Department office and its personnel

Linnanmaa, rooms PR112 and PR114, tel. +358 8 553 1011 (university telephone centre)
Telephone: +358 8 553 2300

Issues related to all Degrees in the department are taken care of by the office personnel.

[4] From 1.8.2011 all PhD-level studies are coordinated by the University of Oulu Graduate School UniOGS, see more information at http://www.oulu.fi/english/research/uniogs/uniogs-admissions

Head of the Department	Mr. Jukka Hiltunen (plus responsible for education)
Vice Head of the Department	Mrs. Riitta Keiski (plus responsible for research)
Student Advisors	Mrs. Saara Luhtaanmäki (PE, EE)
	Mrs. Katri Kosonen (exchange)
	Mrs. Marita Puikkonen (BEE)
Office Personnel	Mrs. Leena Hänninen
	Mrs. Sinikka Rantala
	Mrs. Kaisu Kallio
	Mrs. Hannele Timonen

3.2.5 Student advisors and tutors plus student associations

Student advisors give guidance in all different issues related to studies. DPEE has three student advisors for different groups of students: Mrs. Saara Luhtaanmäki (Process and Environmental Engineering students), Mrs. Katri Kosonen (exchange students and student exchange), and the BEE programme Student Advisor Mrs. Marita Puikkonen (room PR165, phone +358 8 553 2309, email marita.puikkonen [at] oulu.fi) guiding the BEE Master's Programme students in any issues related to their studies at the University of Oulu and elsewhere.

For the first semester of their studies, the BEE students at DPEE will also be provided with a student tutor, a peer student to help new students to begin their studies and to become part of the University community. In addition to initiating the new students to start their studies, they also help with practical issues like visiting various offices. For the new BEE'11 students, the student tutor is Mr. Iiro Sipilä (email isipila [at] mail.student.oulu.fi).

DPEE has two student guilds (students' associations), Prosessikilta for the Process Engineering students, see http://www.prosessikilta.fi, and Ympäristörakentajakilta for Environmental Engineering students (including BEE students), see http://www.ymparistorakentajakilta.net/cms/. All students of the University of Oulu belong to OYY, the Student Union of the University of Oulu, see http://www.oyy.fi/en/. International degree students can join the Network of International Students (NISO), http://nisoportal.org/?page_id=2.

3.3 Studying at the Department of Process and Environmental Engineering

3.3.1 Degree programmes

There are two national Bachelor-level programmes, Process Engineering and Environmental Engineering at the DPEE. Respectively, the Master-level programmes at the department are the two national programmes Process Engineering and Environmental Engineering, and the international Barents Master's Programme in Environmental Engineering. The Master's programme studies are divided to different study orientations and specialisations.

3.3.2 Schedules and the structure of the academic year

The academic year is divided into two semesters (terms), autumn semester and spring semester. In the Faculty of Technology, and Department of Process and Environmental Engineering, each semester is divided into three periods (periods 1-3 on autumn semester, periods 4-6 on spring semester). The periodical study schedules of the BEE-programme can be found at webpage http://pyo.oulu.fi/index.php?46 (see "Periodijaot 2011-2012" in the upper right corner of the page).

The course schedules for the periods are given in the table in the respective page; see rows BEE4/CPO, BEE4/WEO, BEE5/CPO and BEE5/WEO. The schedules give the courses on-going during the specific period, their locations and responsible teachers. In these weekly schedules, the *days* generally imply to all respective days during the whole period, and the given *lesson times*

imply to hours beginning from "fifteen past", the so called "academic quarter". E.g. if the course is scheduled to take place on period 1, on Mondays, at hours 8-9 and 9-10, this means that the course has lessons during the period 1, from the first to the last Monday, at 8:15 to 9:45 (one lesson hour is usually considered to be 45 min long). Exceptions to the schedules are given either within the course information or on the bottom of the column Friday of the before mentioned web page – this information is general in nature, and does not imply to Fridays.

The dates for the periods in the study year 2011-2012 are given in the table below. The dates for periods during the academic year 2012-2013 will be announced later. Please note that courses arranged by other departments or faculties are taught according to timetables followed by the arranging units.

Autumn '11	Period 1	Mon 05.09. – Fri 07.10.2011
	Period 2	Mon 10.10. – Fri 11.11.2011
	Period 3	Mon 14.11. – Fri 16.12.2011
Spring '12	Period 4	Mon 09.01. – Fri 10.02.2012
	Period 5	Mon 13.02. – Fri 23.03.2012
	Period 6	Mon 26.03. – Fri 04.05.2012

3.3.3 Courses and examinations

The courses have names, codes and extents. The course codes are numbered with six-digit figures and a letter. E.g. courses with the code starting with 488 are organised under the different study options (orientations) in the Environmental Engineering programme, and with 477 under Process Engineering, respectively. Code letter A ("aine") represents subject studies and S advanced ("syventävä") studies. For the extents of the courses, ECTS, see the footnote[5].

To participate to a course, the students must enrol (register) to them in the electronic WebOodi system (https://weboodi.oulu.fi/), which the University of Oulu students can access after getting their user accounts (email, etc.). Course information can likewise be found at the WebOodi system. WebOodi is the register of students and their studies in the University of Oulu.

The method of performing a course, i.e. how to pass the course, is always informed by the course organiser / teacher, e.g. the course can be performed by participation to lectures, self-studying, and an examination. Also other methods, e.g. seminars or learning portfolios, etc. are implemented.

The most common examination method is a written final exam arranged after the course at the general examination days of the DPEE (see the link below for details). The examinations of the DPEE courses generally last four hours and are arranged on Fridays at from noon to 4 p.m. Generally, there are two repetitive examinations arranged after the first so called 'course examination'. Enrolment to these examinations must be done at the latest at noon two days before the examination in the WebOodi system. Enrolment to the exams is obligatory. Respectively, if the student is unable to participate to the exam, he/she must cancel the enrolment via WebOodi. Timetables for these examinations can be found at webpage http://pyo.oulu.fi/index.php?324.

[5] **ECTS (European Credit Transfer System)**: The workload of studies is expressed in ECTS credits (in Finnish: *opintopiste, op*) that ease the comparison of different studies. One ECTS credit equals to approximately 27 hours of student-studying-work (26 $^{2}/_{3}$ hours exactly). ECTS is a student-centred system based on the student workload required to achieve the objectives of a study programme, preferably specified in terms of the learning outcomes and competences to be acquired. See also http://ec.europa.eu/education/lifelong-learning-policy/doc48_en.htm.
Ref: http://www.avoinyliopisto.fi/glossary and http://eacea.ec.europa.eu/erasmus_mundus/tools/glossary_en.php

3.3.4 Evaluation and grading of the study performances

The performance of the courses (usually) and also performance of the Master's Thesis are evaluated by numerical grades Passed 1-5 (1 = satisfactory, 2 = very satisfactory, 3 = good, 4 = very good, 5 = excellent). The grade Failed is represented by 0 for course performances. The performance of the courses can also be evaluated with grades Failed or Accepted (*hylätty* and *hyväksytty* in Finnish, respectively).

3.3.5 Personal Study Plan

During the studies, all students in the BEE programme will follow their Personal Study Plan (PSP) which is based on the official curriculum of their orientation. The PSP is prepared in the beginning of the studies together with the BEE Student Advisor. Any changes to the PSP must be accepted by the BEE Student Advisor. At the end of the studies, the PSP will be ratified in the Faculty, especially if there are significant aberrations in the plan compared to the curriculum.

4 THE CURRICULA OF THE BEE MASTER'S PROGRAMME

The study orientation (option) for the BEE programme is first preliminary chosen by the student when he/she applies to the programme. The choice is then officially confirmed during the first autumn semester of the studies.

4.1 Learning outcomes and professional aims of the programme

The graduates of the BEE programme will have scientific approach into environmental protection and management of natural resources, and skills and knowledge for working in industry and academia as environmental engineers. Apart from the hard values, such as technologies, processes, and management skills, the BEE graduates will also be able to address the soft values to improve people's attitudes and raise the awareness on sustainable development internationally. Graduates of the BEE programme will enter the job markets as experts in environmental engineering and skills to understand international contexts of environmental issues, especially in the Barents environmental conditions. The graduates can work in a wide range of business sectors, local and regional public administration as well as environmental authorities or research institutes, not only within the region, but also in international tasks.

4.2 Structure of the Clean Production and Water and Environment orientations

The quadrangular model curriculum structure of the two BEE orientations Clean Production (CP) and Water and Environment (WE) is presented in figure below. In the quadrangular model, each of the four modules consists of approximately 30 ECTS of courses, making totally 120 ECTS, which is minimally required for the Degree of Master of Science in Technology.

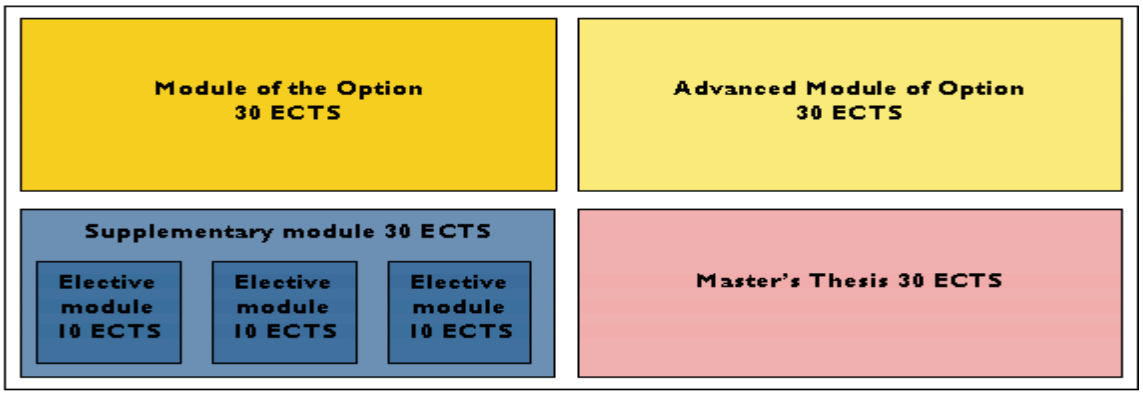
In the first study year, the Basic[6] Module (on autumn semester) and the Advanced Module (on spring) contain mostly the same courses in both orientations. The Basic Module gives the student the basic knowledge of the orientation, and that knowledge is then further deepened in the Advanced and Supplementary Modules.

During the second year, the studies are continued with supplementary courses (Supplementary Module) and the Master's Thesis. The Supplementary Module (second autumn semester) consists of three elective, optional submodules, chosen from a total of five different for each orientation. Finally, the Master's Thesis work in the second year spring semester will finish the studies.

[6] Option = orientation

The Master's Thesis project is an advanced-level study performance of 30 ECTS. The project is planned to be conducted during the second year spring. The student should self search for a suitable project, preferably already during the second year autumn semester at the latest.

The Master's Thesis project consists of project research work, literature search etc., and a written thesis. In the BEE programme, the Master's Thesis is written in English. The thesis project (in Finnish Diplomityö) contains also a compulsory, written maturity test. A maturity test is a written examination, an essay on a topic related to the master's thesis, evaluating the student's ability to write scholarly papers and his/her familiarity with the theories and problems of the thesis. The maturity test must be written without any supporting materials, under supervision. The Master's Thesis is evaluated and accepted by the Department of Process and Environmental Engineering.



The quadrangular model curriculum structure of the BEE orientations Clean Production and Water and Environment

4.2.1 Clean Production orientation

Basic module of Clean Production

Courses of the Basic Module are all compulsory for the students of the orientation. The total content of the module is 31 ECTS. The courses should preferably be performed during the first study year.

After completing this module the student will have an extensive view on especially the Barents region and its environmental and socio-economical characteristics. He/she will understand the multidisciplinary nature of global change and sustainable development, and can apply this know-how on the discipline of technology and engineering. The student knows the most important tools for industrial ecology and can apply them in industry. He/she understands the interactions existing between industrial, biological and socio-economical systems.

CODE	*COURSE*	*ECTS*	*PERIODS*
488400A	Orientation to the BEE studies	1,0	1
488401A	Introduction to the Environmental and Socio-economical Issues of the Barents Region	2,0	1-2
488402A	Sustainable Development	3,0	3
488012A	Environmental Legislation	5,0	2-3
477307S	Research Methodology	5,0	2-6
488404A	Global Change	5,0	1-2
488406A	Introduction to Environmental Science	5,0	4-6
488203S	Industrial Ecology	5,0	2

Information according to DPEE Study Guide 2011-2012, see pages PYO 30-35 at http://pyo.oulu.fi/file.php?1621. Please check the actual names, timing, and ECTS of the courses.

Advanced module of Clean Production

The Advanced Module contains both compulsory and optional (elective) studies. The courses Environmental Issues in the Barents Region and Advanced Practical Training are compulsory* for all CP students. Module content should be approximately 30 ECTS, so that the total minimum content of 120 ECTS in the M.Sc. (Tech.) degree will be filled counting this module together with the supplementary module. The student will plan which courses to take while preparing his/her Personal Study Plan. The courses should preferably be performed during the first study year.

After completing the Advanced Module courses, the student will recognize the most important causes for industrial environmental load. He/she can apply different methods, tools and technologies onto management of environmental load and to handling other environmental issues in industry.

CODE	*COURSE*	*ECTS*	*PERIODS*
488405S	Environmental issues in the Barents region*	5,0*	6
488002S	Advanced practical training*	3,0*	Summer
477203A	Process design	5,0	4-5
477041S	Experimental design	5,0	4-5
477311S	Advanced separation processes	5,0	5
488205S	Environmental load of process industry	4,0	6
477309S	Process and environmental catalysis	5,0	2
488104A	Industrial and communal waste management	5,0	6

Information according to DPEE Study Guide 2011-2012, see pages PYO 30-35 at http://pyo.oulu.fi/file.php?1621. Please check the actual names, timing, and ECTS of the courses.

Supplementary Module for Clean Production

In the Supplementary Module, the CP student will select studies from the different submodules 1-5. All courses are optional (elective). The sum of ECTS of the courses in the three elected submodules should be approximately 30, so that the total content of 120 ECTS in the M.Sc. (Tech.) degree will be filled, counting this module together with the Advanced Module. Please note that the courses in the Submodule 4 are organized either by the Department of Industrial Engineering and Management, or by the Faculty of Economics and Business Administration (Oulu Business School), not by the Department of Process and Environmental Engineering. The other submodules are organized by the DPEE or by the BCBU/BEE universities. The courses should preferably be performed during the first study year, or during the autumn of the second year.

After completing the courses chosen for this module, the student will have more specialized knowledge on the chosen subjects. This module aims also to give the student requisites for his/her Master's Thesis project.

CODE	*COURSE*	*ECTS*	*PERIODS*
Submodule 1 Energy and Environment			
488204S	Air Pollution Control Engineering	5,0	3
488202S	Production and Use of Energy	3,0	1
Submodule 2 Control of Phenomena			
477306S	Non-ideal Reactors	5,0	3
477305S	Flow Dynamics	5,0	2
Submodule 3 Process Design			
477206S	Advanced Process Design	6,0	5-6
477503S	Simulation	3,0	3

Submodule 4 Economics and Management			
555321S	Risk Management	3,0	1-3
721236A	Principles of Environmental Economics	5,0	4-5
721704A	Business logistics	5,0	2-3
Submodule 5 Elective Courses			
	Courses by or at the BEE partner universities	10,0	1-3

Information according to DPEE Study Guide 2011-2012, see pages PYO 30-35 at http://pyo.oulu.fi/file.php?1621. Please check the actual names, timing, and ECTS of the courses.

4.2.2 Water and Environment orientation

Basic Module of Water and Environment

Courses of the Basic Module are all compulsory for the students of this orientation. The total content of the module is 30 ECTS. The courses should preferably be performed during the first study year.

After completing this module the student will have an extensive view on especially the Barents region and its environmental and socio-economical characteristics. He/she will understand the multidisciplinary nature of global change and sustainable development, and can apply this know-how on the discipline of technology and engineering. The student knows the most important methods for water and waste water treatment, and can manage the basic practices in the laboratory and field work in environmental engineering.

CODE	*COURSE*	*ECTS*	*PERIODS*
488400A	Orientation to the BEE studies	1,0	1
488401A	Introduction to the Environmental and Socio-economical issues of the Barents Region	2,0	1-2
488402A	Sustainable Development	3,0	3
488012A	Environmental Legislation	5,0	2-3
477307S	Research Methodology	5,0	2-6
488118S	Laboratory and Field Measurements in Environmental Engineering	10,0	1-6
488110S	Water and Wastewater Treatment	5,0	1-2

Information according to DPEE Study Guide 2011-2012, see pages PYO 30-35 at http://pyo.oulu.fi/file.php?1621. Please check the actual names, timing, and ECTS of the courses.

Advanced Module of Water and Environment

The Advanced Module contains both compulsory and optional (elective) studies. The courses Environmental Issues in the Barents Region and Advanced Practical Training are compulsory* for all WE students. Module content should be approximately 30 ECTS, so that the total minimum content of 120 ECTS in the M.Sc. (Tech.) degree will be filled, counting this module together with the Supplementary Module. The student will plan which courses to take while preparing his/her Personal Study Plan. The courses should preferably be performed during the first study year.

After completing this module, the student will recognize the most important causes for environmental load especially in the Barents region and can apply different methods, tools and technologies in controlling and reducing harmful environmental effects. The student also understands the natural phenomena and processes related to water resources.

CODE	*COURSE*	*ECTS*	*PERIODS*
488405S	Environmental Issues in the Barents Region*	5,0*	6
488002S	Advanced Practical Training*	3,0*	Summer
488102A	Hydrological processes	5,0	4-5
477041S	Experimental design	5,0	4-5
477311S	Advanced separation processes	5,0	5
477203A	Process design	5,0	4-5
488104A	Industrial and communal waste management	5,0	6

Information according to DPEE Study Guide 2011-2012, see pages PYO 30-35 at http://pyo.oulu.fi/file.php?1621. Please check the actual names, timing, and ECTS of the courses.

Supplementary Module for Water and Environment

In the Supplementary Module, the WE student will select studies from different submodules 4-8. All the courses are optional (elective). The sum of ECTS of the courses in the three elected modules should be approximately 30, so that the total content of 120 ECTS in the M.Sc. (Tech.) degree will be filled, counting this module together with the Advanced Module. Please also note that the courses in the Submodule 4 are organized by either the Department of Industrial Engineering and Management, or the Faculty of Economics and Business Administration. The other submodules are organized by the Department of Process and Environmental Engineering or by the BEE partner universities). Courses in the Submodule 6 are available on every second year, the courses in Submodule 6a on odd years (2011, 2013), and the courses in Submodule 6b on even years (2012, 2014). The courses should preferably be performed during the first study year, or during the autumn of the second year.

After completing the courses chosen for the Supplementary Module, the student will have more specialized knowledge on the chosen subjects. This module aims also to give the student requisites for his/her Master's Thesis project.

CODE	*COURSE*	*ECTS*	*PERIODS*
Submodule 4 Economics and Management			
555321S	Risk Management	3,0	1-3
721236A	Principles of Environmental Economics	5,0	4-5
721704A	Business logistics	5,0	2-3
Submodule 5 Elective Courses			
	Courses by or at the BEE partner universities	10,0	1-3
Submodule 6a Water 1(available only on odd years, next time 2011)			
488108S	Groundwater Engineering	5,0	1-2
488117S	Water Resources Management	7,5	2-3
Submodule 6b Water 2 (available only on even years, next time 2012)			
488103A	Environmental Impact Assessment	5,0	2-3
488113S	Hydraulics for Environmental Engineering	5,0	2-3
Submodule 8 Environmental Systems			
488203S	Industrial Ecology	5,0	2
488404A	Global Change	5,0	1-2

Information according to DPEE Study Guide 2011-2012, see pages PYO 30-35 at http://pyo.oulu.fi/file.php?1621. Please check the actual names, timing, and ECTS of the courses.

4.3 Structure of the Sustainable Energy orientation

Even though the Sustainable Energy (SE) orientation is not actually a true BEE orientation, but a one study option in the two national Master's Degree programmes of the Department and Environmental Engineering, its contents and structure are described here.

The curriculum of the SE orientation applies the same quadrangular model structure as do the CP and WE curricula. In the model, each of the four modules consists of approximately 30 ECTS of courses, making totally the 120 ECTS minimally required for the Master's Degree. In the first Master's study year (the 4th year of the complete studies) autumn, the SE student will take the Basic Module and on spring, the Advanced Module.. The Basic Module gives the student the basic knowledge, and that knowledge is then further deepened in the Advanced and Supplementary Modules. During the second Master's year, the studies are continued with the supplementary courses (Supplementary Module) and Master's Thesis. The Supplementary Module (second autumn semester) is performed in Norway, in the Narvik University College as exchange studies. Finally, the Master's Thesis work in the second year spring term finalizes the studies.

Basic Module of Sustainable Energy (Basic SE)

Courses of the Basic Module are all compulsory for the students of the orientation. The total content of the module is 30 ECTS and it will be carried out at the University of Oulu.

After completing this module, the student will have an extensive view of the Barents region and its environmental and socio-economical characteristics. He/she will understand the multi-disciplinary nature of global change and sustainable development, and can apply this know-how on the discipline of technology and engineering. The student knows the most important tools for industrial ecology and can apply them in industry. He/she understands the interactions existing between industrial, biological and socio-economical systems. In addition, the student can manage the basics of the production, delivery and use of energy, and is familiar to the structure of the energy markets in Finland. He/she will also recognise the questions related to the most important energy sources, their delivery and sufficiency, and environmental protection.

CODE	*COURSE*	*ECTS*	*PERIOD*	*YEAR*
488401A	Introduction to the Environmental and Socio-Economical Issues of The Barents Region	2,0	1,2	IV
488402A	Sustainable Development	3,0	3	IV
488012A	Environmental Legislation	5,0	2,3	IV
488404A	Global Change	5,0	1,3	IV
477321S	Research Ethics	3,0	3	IV
488202S	Production and Use of Energy	3,0	I	IV
488203S	Industrial Ecology	5,0	2	IV
488204S	Air Pollution Control Engineering	5,0	3	IV

Information according to DPEE Study Guide 2011-2012, see http://pyo.oulu.fi/file.php?1621. Please check the actual names, timing, and ECTS of the courses.

Advanced Module of Sustainable Energy (Advanced SE)

The Advanced Module contains both compulsory and optional (elective) studies. Courses *Environmental Issues in the Barents Region,* and *Introduction to the Sustainable Energy* (provided by Narvik University College), and *Advanced Practical Training* are compulsory* for all SE orientation students. Please note that course *Advanced separation processes*** is only given every second year (next time on spring 2012). The module content should be approximately 30 ECTS, so that the total minimum content of 120 ECTS in the M.Sc. (Tech.) degree will be filled, counting this

module together with the Supplementary Module. The student will plan which courses to take, while preparing his/her Personal Study Plan.

After completing the Advanced Module courses, the student will recognise the most important causes for industrial environmental load. He/she can apply different methods, tools and technologies onto the management and reduction of harmful environmental effects. The student is familiar with the most common systems in energy production and energy delivery and can define the most important environmental loads caused by them. He/she knows the distinctive characters, and is able to estimate the environmental effects of sustainable energy, and compare the benefits, possibilities and consequences of the different energy production and delivery systems.

CODE	*COURSE*	*ECTS*	*PERIOD*	*YEAR*
488405S	Environmental Issues in The Barents Region*	5,0	6	IV
488410A	Introduction to Sustainable Energy*	10,0	4-6	IV
488002S	Advanced Practical Training*	3,0	Summer	IV/V
477311S	Advanced Separation Processes**	5,0	6	IV
477041S	Experimental Design	5,0	4	IV
477309S	Environmental and Process Catalysis	5,0	2	IV
488104A	Industrial and Communal Waste Management	5,0	6	IV
488205S	Environmental Load Of Process Industry	4,0	6	IV

Information according to DPEE Study Guide 2011-2012, see http://pyo.oulu.fi/file.php?1621. Please check the actual names, timing, and ECTS of the courses.

Supplementary Module for Sustainable Energy

The Supplementary Module for the Sustainable Energy orientation is compulsory for all SE students and will be carried out at the Narvik University College, Norway, during the autumn semester* of the fifth study year (second Master's degree year) as exchange studies. The module consists of two compulsory submodules and the total content of the module is 30 ECTS.

After completing the courses chosen for the Supplementary Module, the student will have more specialized knowledge on the chosen subjects. The student will be able to extensively handle technologies used in the sustainable energy production, energy efficiency and saving, in industry as well as in building especially in the Northern areas. This module aims also to give the student requisites for his/her Master's Thesis project, especially this applies to the Project Work.

CODE	*COURSE*	*ECTS*	*PERIOD**	*YEAR*
488420S	Solar and Wind Energy	10,0	1-3*	V
488421S	Bioenergy	5,0	1-3*	V
488422S	Energy Systems in Buildings and Industry	5,0	1-3*	V
488423S	Project Work (Pre-Master Work)	10,0	1-3*	V

Information according to DPEE Study Guide 2011-2012, see http://pyo.oulu.fi/file.php?1621.

* Please note that here Period 1-3* refers to the timing of the autumn semester of the Narvik University College, which starts already in the middle of August, differently from the autumn semester of the University of Oulu, which starts on the beginning of September.

Master's Thesis for Sustainable Energy 30 ECTS

The Master's Thesis project is an advanced-level study performance of 30 ECTS. The project is planned to be conducted during the second Master's year spring. The student should search for a suitable project self, preferably already during the second year autumn at the latest. The Master's project of the Sustainable Energy orientation student can be conducted either in Finland or in Norway, depending on the subject of the thesis. The Master's Thesis is supervised, evaluated and accepted both by the Department of Process and Environmental Engineering in Finland, and by the Narvik University College in Norway.

The Master's Thesis project consists of a project research work, literature search etc., and a written thesis. The Master's Thesis project (in Finnish Diplomityö) contains also a compulsory, written maturity test. A maturity test is a written examination, an essay on a topic related to the master's thesis, evaluating the student's ability to write scholarly papers and his/her familiarity with the theories and problems of the thesis. The maturity test must be written without any supporting materials, under supervision.

5 COURSE DESCRIPTIONS

5.1 COURSES IN THE UNIVERSITY OF OULU, FINLAND

The courses belonging to the BEE programme orientations CP and WE curricula organized by DPEE are described in the DPEE Study Guide 2011-2012. Search the courses by course codes or names. The course descriptions are also given in WebOodi, where all the University of Oulu courses are described; please see https://weboodi.oulu.fi/oodi/.

In WebOodi you can also find those courses that are organized by other Departments than DPEE (e.g. by the Department of Industrial Engineering and Management, or by the Faculty of Economics and Business Administration). You can find these course descriptions for BEE (CP, WE) also below (search by codes or names). For more information about the courses, you can also contact your Study Advisor or the course teacher personally.

488002S Advanced practical training

Credits: 3 cr[7], corresponding to two months of working

Timing: The summer between the first and second years, and seminar in the preceding autumn

Objective: To give the student a deeper and more detailed conception of the industrial area where the student will possibly work after the MSc-graduation. Suitable places for the training (usually taken as summer jobs) would be e.g. supervision and R&D tasks, so that the student becomes familiar with practical work, work safety, as well as with the social nature of the working environment. Advanced Practical Training should nurture the theoretical studies of the student. In addition the training should give the student a general idea about the company where the training takes place, and about its technical and organizational operations, financial management and supervision. Students should find the summer jobs themselves.

Learning outcomes: During the Advanced Practical Training the student orients to his/her working environment from the point of view of his/her studies and becomes acquainted with a possible future job, or to a different assignment already in a familiar working environment. After the Advanced Practical Training, the student can identify the problems associated with the working environment and can propose improvements to those. The student can apply

[7] cr = credits = ECTS

theoretical knowledge in practical tasks. The student can describe points of contact between working life and studies. The student can identify tasks at his/her workplace that would be appropriate for a M.Sc. (Tech.) Engineer.

Contents: Suitable areas for practical training are, for example, the chemical industry, the pulp and paper industry, the metallurgical and mining industry, the biotechnological and food industry, and partly the electronics and automation industry.

Working methods and mode of delivery: Supervised practical training (during summer job) for minimally 9 weeks or 2 months, and an oral presentation in a seminar (5-10 min)

Responsible person: Student advisor Saara Luhtaanmäki, and Marita Puikkonen in the international students' seminar as supervisor

Language of instruction: English

477041S Experimental Design

Credits: 5,0 cr

Timing: Implementation in 4th period.

Objective: To provide the student with understanding of the measurements uncertainty evaluation and calculation as well as ideas of implementing this information in experimental and computational research and measurements.

Learning outcomes: After this course the student knows the main software tools for experiment design and is able to use them. He can apply the main approaches for studying and evaluating the measurement reliability.

Contents: Determining the uncertainty of measurements in chemical, physical and biochemical measurements, measurements reliability and traceability; Calculation examples supporting the learning of measurements uncertainty assessment preparation; Experimental design software (Modde, Minilab, Matlab tools); Experimental design preparation and execution in laboratory scale research. Test methods and variable significance, reliability of experimental data;Problems in laboratory, pilot and full scale experiments, problems in modelling and in simulation.

Working methods and mode of delivery: Lectures and practical work. Assessment during the course, by continuous evaluation with lecture exams, and written report of the practical work.

Study materials: Material given in the lectures.

Responsible person: Professor Kauko Leiviskä

Language of instruction: English

477203A Process design

Credits: 5 cr

Timing: Periods 4-5.

Objective: Chemical process design principles

Learning outcomes: By completing the course the student is able to identify the activities of process design and the know-how needed at different design stages. The student can utilise process synthesis and analysis tools for creating a preliminary process concept and point out the techno-economical performance based on holistic criteria.

Contents: Acting in process design projects, safety and environmentally conscious process design. Design tasks from conceptual design to plant design, especially the methodology for basic and plant design.

Working methods and mode of delivery: Lectures and design group exercises.

Prerequisites and co-requisites: Objectives of 477202A Reactor analysis, 477304A Separation processes and 477012 Introduction to Automation Engineering

Study materials: Lecture handout, Seider, W.D., Seider, J.D. and Lewin, D.R. Product and process design principles: Synthesis, analysis and evaluation. John Wiley & Sons, 2004. (Parts) ISBN 0-471-21663-1

Assessment methods and criteria: Combination of examination and design group exercises.

Responsible person: University Lecturer Juha Ahola

Language of instruction: English

477206S Advanced process design

Credits: 6 cr

Timing: Periods 5-6

Objective: The student learns how to adapt the skills from previous courses in a process design project.

Learning outcomes: The student is able to produce a preliminary chemical process concept. She/he can apply systematic process synthesis tools, chemical process simulation tools and whole process performance criteria in the conceptual process design phase. Furthermore, the student is able to produce process design documents. The student will acquire skills how to work as a member in an industrial chemical process design project. She/he will experience by team work the hierarchical character of the conceptual process design, the benefits of the systematic working methods and the need to understand the whole process performance when optimal design is sought. The student understands the importance of innovation and creative work.

Contents: Conceptual process design and hierarchical decision making. Heuristics of process design. Design methodology: synthesis, analysis and evaluation. Design cycle. Performance evaluation of the chemical processes. Team work and meetings.

Working methods and mode of delivery: Design projects in small groups.

Prerequisites and co-requisites: Objectives of 477203A Process Design

Study materials: Lecture handout, Seider, W.D., Seider, J.D. and Lewin, D.R. Product and process design principles: Synthesis, analysis and evaluation. John Wiley & Sons, 2004. (Parts) ISBN 0-471-21663-1

Assessment methods and criteria: Project work with reporting.

Responsible person: University Lecturer Juha Ahola

Language of instruction: English

477305S (Flow dynamics) Virtausdynamiikka

Credits: 5 cr

Timing: Period 2

Objective: To familiarize the student with mathematical modeling of flow phenomena using computational fluid dynamics (CFD).

Learning outcomes: After completing the course the student is able to formulate the partial differential equations describing flow and to solve these equations in systems with simple geometry using difference, finite element and finite volume methods. He/she is able to choose the experimental methods for validation of the calculated results and the methods to measure the most common properties describing fluid flow. After the course the student is able to model simple flow configurations and to design experimental systems and measurements for verifying computational results.

Contents: Equations in fluid dynamics. Partial differential equations. Difference method. Graphical representation. Modelling the turbulence. Finite element method. Finite volume method. Experimental fluid dynamics.

Working methods and mode of delivery: Lectures and compulsory exercise done in small groups. Examination.

Prerequisites: Courses Momentum Transfer 477301A, Matrix Algebra and Numerical Methods are recommended.

Study materials: Anderson J.D.: Computational Fluid Dynamics, McGraw-Hill, 1995, 608 pp. Versteeg, H.K. & Malalasekera, W.: An Introduction to Computational Fluid Dynamics, Longman Scientific and Technical, 1995, 257 pp. Tavoularis, S.: Measurements in Fluid Mechanics, 2005, 354 pp. Additional literature: Shaw, C.T.: Using Computational Fluid Dynamics, Prentice Hall, 1992, 251 pp.; Nakayama, Y. & Boucher, R.F.: Introduction to Fluid Mechanics, Arnold, 1999, 308 pp.; Rathakrishnan, E.: Instrumentation, Measurements, and Experiments in Fluids, 2007, 492 pp.

Responsible person: Laboratory engineer Esa Muurinen

Language of instruction: Finnish, but the course can also be performed in English – please contact the teacher (E. Muurinen) in advance.

477306S Non-ideal reactors

Credits: 5 cr

Timing: Implementation in 3rd period.

Objective: By means of the residence time distribution theory, students adopt a way of thinking in modeling which is based on the concept of probability.

Learning outcomes: After completing the course the student can analyze the effect of non-ideal mixing conditions on the behavior of a reactor. He/she is capable of explaining the mechanisms of heterogeneous reactions, especially with methods that are used to analyze the effect of mass and heat transfer on the observed kinetics of heterogeneous reactions. The student has rudimentary skills to conduct demanding reactor analysis and to design heterogeneous reactors.

Contents: Mixing models of a flowing material. Residence time distribution theory. Heterogeneous catalysis and biochemical reactions: mechanisms, mass and heat transfer, and reactor design. Gas-liquid reactions: mechanisms, mass transfer, and reactor design. Design heuristics. Microreactors.

Working methods and mode of delivery: Lectures including exercises.

Prerequisites and co-requisites: Courses 477201A Energy and Material Balances and 477202A Reactor Analysis are recommended beforehand.

Study materials: Nauman, E.B.: Chemical Reactor Design. New York, John Wiley & Sons. 1987; Winterbottom, J.M. & King, M.B. (Editors) Reactor Design for Chemical Engineers. Padstow 1999, T.J. International Ltd. 442 s.

Additional literature : Gianetto, A. & Silveston, P.L.: Multiphase Chemical Reactors: Theory, Design, Scale-up. Hemisphere, Washington, D. 1986; Froment, G. & Bischoff, K.B.: Chemical Reactor Analysis and Design. New York, John Wiley & Sons. 1990; Hessel, V., Hardt, S. & Löwe, H.: Chemical Micro Process Engineering. Weinheim 2004, Wiley-VHC Verlag GmbH & Co. 674 p, Salmi, T., Mikkola, J.-P. & Wärnå, J. Chemical reaction engineering and reactor technology. Boca Raton 2011, CRC Press, 615 p.

Assessment methods and criteria: Examination.

Responsible person: Professor Riitta Keiski

Language of instruction: English

477307S Research methodology

Credits: 5 cr

Timing: Implementation in periods 2-6.

Objective: To familiarize the student with scientific research, scientific methods and data handling, especially in process and environmental engineering. The course will give the student the basis to do the research work and motivates him/her to begin post-graduate studies. The course gives the student team working skills and increases the co-operation between the students and the research and teaching staff. The students are exposed to experiences in co-operation between different fields of science, industry, and other universities and laboratories, as well as the skills for doctoral studies.

Learning outcomes: After the course the student is able to define the role of research and different stages of research work. The student is also able to classify the stages and the subtasks of research work as well as important elements related to research, i.e. literature search, experimental work, and data processing. In addition, the student can evaluate the amount of work needed in research stages. The student can write scientific text and use references appropriately. The student also has the ability to recognise ethical issues related to research and analyse the meanings of those. He/she can use the principles of good scientific practises and is able to apply knowledge to research work.

Contents: 1) Science and research politics. 2) Research education. 3) Fundamentals of philosophy of science. 4) Starting research work: research types, funding, the process of research work, finding the research area, choosing the research topic, information sources. 5) Research plan and collecting data, experimental methods and significance of the variables, systematic experimental design, collecting experimental data, test equipment, reliability of the results, problems in laboratory experiments, modelling and simulation. 6) Mathematical analysis of results. 7) Reporting: writing a scientific text, referring, writing diploma, licentiate and doctoral theses, or reports. 8) Other issues connected to research work: ethical issues, integrity, and future. 9) Examples of scientific research in practice.

Working methods and mode of delivery: Miniproject based on lectures in Optima during autumn term, contact lectures, laboratory training period during spring term.

Prerequisites and co-requisites: none

Study materials: Melville, S & Goddard, W: Research Methodology; An Introduction for Science and Engineering Students. Kenwyn 1996, Juta & Co. Ltd. 167 p. Hirsijärvi, S., Remes, P. & Sajavaara, P.: Tutki ja kirjoita. Jyväskylä 2004, Gummerus Kirjapaino Oy. 436 p. Material introduced in the lectures.

Additional literature : Paradis, J.G. & Zimmermann, M.L.: The MIT Guide to Science and Engineering Communication, 2nd ed. Cambridge 2002, The MITPress, 324 p. Nykänen, O.: Toimivaa tekstiä, Opas tekniikasta kirjoittaville. Helsinki 2002, Tekniikan Akateemisten Liitto TEK. 212 p.

Assessment methods and criteria: Optima exercises (miniproject) and laboratory training

Responsible person: University researcher Mika Huuhtanen

Language of instruction: English

477309S Process and environmental catalysis

Credits: 5 cr

Timing: Implementation in 2th period

Objective: Introducing the history, principles and economical and environmental meaning of catalysis, the design, selection and testing of catalysts and catalytic reactors and processes, and the most important industrial catalytic processes.

Learning outcomes: After the course the student is able to define the fundamentals and history of catalysis and he/she can explain the economical and environmental meaning of catalysis. The student is capable of specifying the design, selection and testing of catalysts and catalytic reactors and processes. He/she is able to explain the most important industrial catalytic processes, the use of catalysts in environmental technology, catalyst research and the significance of an interdisciplinary approach in the preparation, development and use of catalysts. He/she recognizes the connection between catalysis and green chemistry and the role of catalysis in sustainable processes and energy production.

Contents: Definition of catalysis and a catalyst, history of catalysis, economical, social and environmental meaning. Preparation of catalysts, principles, selection, design and testing of catalysts and catalytic reactors. Kinetics and mechanisms of catalytic reactions, catalyst deactivation. Industrially important catalysts, catalytic reactors and catalytic processes. Environmental catalysis. Catalysts in air pollution control and purification of waters and soil. Catalysis and green chemistry. Catalysis for sustainability. Principles in the design of catalytic processes.

Working methods and mode of delivery: Lectures including design exercises.

Prerequisites and co-requisites: The courses 477011P Introduction to Process Engineering, 488011P Introduction to Environmental Engineering and 780109P Basic Principles in Chemistry are recommended beforehand

Study materials: Lecture handout; Richardson, J.T.: Principles of Catalyst Development. New York. 1989, 288 pp.; Janssen, F.J.J.G. & van Santen, R.A.: Environmental Catalysis. NIOK, Catalytic Science Series, Vol. 1. 1999. 369 pp.

Additional literature: Ertl, G., Knözinger, J. & Weitkamp, J.: Handbook of Heterogeneous Catalysis. Vol. 1-5. Weinheim. 1997, 657 p.; Thomas, J.M. & Thomas, W.J.: Principles and Practice of Heterogenous Catalysis. Weinheim 1997. 657 pp.; Somorjai, G.A.: Surface Chemistry and Catalysis. New York 1994, 667 pp.; van Santen, R.A., van Leuwen, P.W.N.M., Mouljin, J.A. & Averill, B.A.: Catalysis: An Integrated Approach, 2nd ed. Studies in Surface Science and Catalysis 123. Amsterdam 1999, Elsevier Sci. B.V. 582 pp.

Assessment methods and criteria: Written examination.

Responsible person: University researcher Mika Huuhtanen

Language of instruction: English

477311S Advanced separation processes

Credits: 5 cr

Timing: Implementation in 6th period every even year.

Objective: The course reviews the recent methods and techniques for separation and purification of components and products e.g. in chemical, food, biotechnology industry. The course introduces new research innovations in separation processes.

Learning outcomes: After completing the course the student is able to review the most recent methods and techniques for separation and purification of components and products, e.g. in the chemical, food, and biotechnology industries. He/she is able to define the principles of green separation processes and their research status and potentiality in industrial applications.

Contents: The course is divided into lectures given by visiting experts from different fields (industry, research institutes and universities) and seminars given by students and senior researchers. The lectures open up the newest innovations in separation and purification technologies. The lectures can include for example the following themes: Phenomena in Supercritical fluid extraction, Pressure-activated membrane processes, Reverse osmosis, Nanofiltration, Ultrafiltration, Microfiltration, Pervaporation, Polymer membranes, Dialysis, Electrolysis and Ion-exchange, Forces for adsorption and Equilibrium adsorption isotherms, Sorbent materials and heterogeneity of surfaces, Predicting mixture adsorption, Rate processes

in adsorption/adsorbers and adsorber dynamics, Cyclic adsorption processes, Temperature and pressure swing adsorption. Innovative separation methods, Phenomena integration, New hybrid materials as separation agents. Fluids and their application in gas extraction processes, Solubility of compounds in supercritical fluids and phase equilibrium. Extraction from solid substrates: Fundamentals, hydrodynamics and mass transfer, applications and processes (including supercritical water and carbon dioxide). Counter-current multistage extraction: Fundamentals and methods, hydrodynamics and mass transfer, applications and processes. Solvent cycles, heat and mass transfer, methods for precipitation. Supercritical fluid chromatography. Membrane separation of gases at high pressures. The topics of the course seminars will change annually depending on the research relevance.

Working methods and mode of delivery: With the lectures the students will familiarize themselves to the latest research publications.

Prerequisites and co-requisites: The courses 477304A Separation Processes and 477308S Multicomponent Mass Transfer are recommended beforehand.

Study materials: The course literature will be chosen when the course is planned. Latest scientific research articles.

Additional literature: Separation Processes in the Food and Biotechnology Industries, Edited by: Grandison, A.S. & Lewis, M.J. 1996 Woodhead Publishing.

Assessment methods and criteria: Seminars. Written examination. This course is proposed to be taken within the Research module.

Responsible person: Professor Riitta Keiski

Language of instruction: English

477321S Research ethics

Credits: 3 cr

Timing: Implementation in 4th period.

Learning outcomes: After the course the student is capable of explaining the meaning of research ethics and good scientific practice including honesty, conscientiousness and precision in research work. The student is able to plan, carry out and report his/her research work, and is aware of the rights and duties of a researcher and their actions and respect towards other researchers. The student is able to recognise misconduct and fraud in scientific practices and has an awareness of how to handle misconduct.

Contents: Ethically good research, Scientific community and ethical problems in research work. Professional ethics of a researcher and an engineer. Good scientific practices and handling of misconduct and fraud in science. Regulations and rules. Definitions, Characteristic features of science, Research results and responsible persons in scientific work, Ethics and research ethics, Professional ethics of a researcher, Research ethics in Finland and globally, Instructions for preventing, handling and examining misconduct and fraud in good scientific practices and scientific research, Good scientific practices and responsibility in performing research, Good practices in selecting the research problem, collecting the material, planning and performing the research, publishing, using and applying the results, Protection of a researcher under the law, Examples and statistics.

Working methods and mode of delivery: Lectures and team work.

Study materials: Clarkeburn, H. & Mustajoki, A. Tutkijan arkipäivän etiikkaa. Tampere 2007, Vastapaino. 319 p., Good scientific practice and procedures for handling misconduct and fraud in science. Helsinki 2002, TENK, National Advisory Board on Research Ethics., Guidelines for the Prevention, Handling and Investigation of Misconduct and Fraud in Scientific Research. Helsinki 1998, TENK, National Advisory Board on Research Ethics., Martin, M.W. & Schinzinger, R. Ethics in Engineering, 4th Edition. New York, 2005, McGraw Hill Co. 339 p.

Additional literature: Hallamaa, J., Launis, V., Lötjönen, S. & Sorvali, I. Etiikkaa ihmistieteille. Tietolipas 211, Suomen Kirjallisuuden Seura, Helsinki 2006. 428 p., Pietilä, A.-M. & Länsimies-Antikainen, H. (Toim.) Etiikkaa monitieteisesti, Pohdintaa ja kysymyksiä. Kuopio 2008, Kuopio University Publications F. University Affairs 45. 224 p.

Assessment methods and criteria: Homework assignments affect the course grade. Examination or a learning diary.

Responsible person: Professor Riitta Keiski

Language of instruction: English

477503S (Simulation) Simulointi

Credits: 3 cr

Ajoitus: Period 3

Objective: To provide advanced understanding on the methodologies and applications of simulation.

Learning outcomes: After the course the student is capable of explaining the concepts and operation principles of process simulators. The student has skills to construct simulation models in Matlab-Simulink environment and to explain the operation of these models. The student recognizes the key problems of the simulation and is able to choose suitable modeling solutions in process modeling and control. Moreover, the student is able to use key concepts of event based, interactive and distributed simulation. After the course the student is able to search other relevant simulation languages and programming tools.

Contents: Modelling, modular and equation based simulation, dynamic simulation, intelligent methods in simulation, simulation in automation, event handling in continuous simulation, simulation of production processes, distributed simulation, integration with other systems, simulation languages and programming tools.

Working methods and mode of delivery: The course consists of lectures, several exercises, a case study, two seminars and a final report. The case study covers several topics applied in a chosen problem. Each seminar presentation concentrates on a single topic. The final grade is based on the combined points from exercises, case study, seminar and the final report. Final exam is an alternative for the final report. Reports and exams can be done in Finnish or in English.

Study materials: Lecture notes and exercise materials. Material is in Finnish and in English.

Responsible person: University teacher Esko Juuso

Language of instruction: Finnish and English

488012A Environmental legislation

Credits: 5 cr

Timing: In periods 2 and 3

Objectives: To provide basic knowledge from environmental legislation.

Learning outcomes: After the course, student is able to name main international conventions of environmental protection and legislation and explain their main contents. Student is also able to name main sectors of environmental legislation and principles of environmental legislation and is able to explain the meaning and importance of these principles. Student is able to explain the basics of international environmental legislation and co-operation among European Union. Student understands the structure of environmental administration in governmental and municipal level; authorities, jurisdiction and duties. Student knows the building permit and other permits related to land use and building. Student knows also mining legislation and other

legislation related to the life cycle of mine (foundation, operation, and close down safety matters). Student is able to analyze and explain the main plan types and permits of modern industry and power plants including renewable energy and nuclear energy from the point of view of land use and building act, environmental protection act, water act and nuclear energy act, and act on environmental impact assessment procedure.

Contents: Legislation of environmental protection and use of natural resources in Finland and Europe. Environmental administration and legislation. Environmental permits (permits related to land use and building, permits related to water legislation, permits related to nature conservation, permits related to environmental protection). Mining legislation and other legislation related to the life cycle of mine (foundation, operation, close down). Environmental Impact Assessment (EIA) and EIA procedure. Pollution control and prevention. International conventions and organizations. Basics of international environmental legislation and co-operation among European Union in the field of environmental legislation.

Working methods and mode of delivery: Lectures and seminar

Study materials: Materials in English will be delivered at lectures; lecture materials

Assessment methods and criteria: Course assignment and seminar

Responsible person: University lecturer A-K Ronkanen

Language of instruction: English

488102A (Hydrological processes) Hydrologiset prosessit

Credits: 5 cr

Timing: Periods 4-5

Objectives: To provide a basic understanding of water flow and storage processes involved in the hydrological cycle and introduce engineering computational methods used to manage water resources in natural and man-made environments.

Learning outcomes: The student will be able to explain the main hydrological processes quantitatively through mathematical methods.

Contents: Hydrological cycle, physical properties of water, distribution of water resources, water balance, precipitation, evapotranspiration, soil and ground water, infiltration, runoff, snow hydrology, hydrometry, water quality, rivers and lakes.

Working methods and mode of delivery: Lectures 24 h, exercises 12 h, and an assignment

Prerequisites: Course Taselaskenta (Material and Energy Balances) or book Reklaitis, G.V.: Introduction to Material and Energy Balances. John Wiley & Sons, 1983 (recommended)

Study materials: Lecture notes, solved exercises, Fluid Mechanics and Hydraulics (Giles RV, 1995, 3rd Edition, ISBN 0-07-020509-4). Physical Hydrology (Dingman SL, 2002, 2nd Edition, ISBN 978-1-57766-561-8)

Assessment methods and criteria: Examination (grades 1-5), the assignment (accepted/not accepted), peer review (accepted/not accepted)

Responsible person: Prof. B. Klöve

Language of instruction: Finnish, but the course can also be performed in English – please contact the teacher (Klöve) in advance.

488103A Environmental impact assessment

Credits: 5-8 cr (5 cr plus max. 3 extra cr)

Timing: In periods 1-4

Objectives: To provide a broad and multidisciplinary and sustainable approach to environmental impact assessment (EIA).

Learning outcomes: The student will know the EIA process and the different methods used in environmental impact assessment.

Contents: EIA process and legislation, environmental change, principles and assessment methods in ecology, hydrology, economics and social sciences.

Working methods and mode of delivery: The course is organised in a co-operation with faculty of Technology, Economics, Social Sciences, Biology and the Thule institute. The course contains lectures and assignments.

Prerequisites and co-requisites: Introduction to Environmental Engineering or comparable knowledge.

Study materials: Environmental Impact Assessment: Cutting Edge for the Twenty-First Century (Gilpin A, 1995, ISBN 0-521-42967-6). Lecture handout and other materials delivered in lectures.

Assessment methods and criteria: The course includes five modules, which are evaluated separately (with the scale 1-5). Assessment methods vary including learning diaries and different kind of assignments.

Responsible person: Prof. B. Klöve

Other information: Lectures are given in every second years.

Language of instruction: English

488104A Industrial and communal waste management

Credits: 5 credits

Timing: periods 5-6

Objectives: To present the students with an overview of the waste produced by communities and industries, as well as to offer an introduction to waste management methods, technical principles and terminology and waste management legislation.

Learning outcomes: Student will understand what waste is, where it is produced and how to prevent it. Student will be familiar with waste management hierarchy and how waste legislation regulates waste management. She/he will get basic knowledge about waste treatment methods and planning waste management.

Contents: Waste management hierarchy, waste sorting, logistics, waste prevention in industries, waste legislation, treatment of different industry waste, hazardous waste, municipal waste, biological waste treatment.

Working methods and mode of delivery: The course is offered as a series of lectures given by specialists. It also includes field visits and waste-mapping assignment.

Study materials: Lecture handout, notes and other materials delivered in lectures. Waste management: a reference handbook illustrated edition, 2008 (electronic book, ISBN 9781598841510).

Assessment methods and criteria: Exercises 1 and 2 and examination are graded on the scale 1-5.

Responsible person: N.N

Language of instruction: English

488108S (Groundwater engineering) Pohjavesitekniikka

Credits: 5 cr

Timing: Periods 1-2 (every second year, on odd autumn years)

Objectives: To acquire knowledge on water retention and flow in soils, hydraulics of ground water systems, ground water quality, ground water use and modelling.

Learning outcomes: Students will be able to define hydraulic characteristics of soil and aquifers. Students can estimate key factors influencing on discharge and water quality of groundwater. Students can use general methods to calculate groundwater flow and design sustainable use and management of groundwaters.

Contents: Soil and ground water, water balance, hydraulic properties of soils, formation of ground water, flow equations and solutions, pumping tests and methods, ground water quality and modelling.

Working methods and mode of delivery: Lectures, calculus assignments, modelling tasks (GMS-MODFLOW)

Prerequisites : Course Hydrological Processes

Study materials: Lecture notes, Physical and Chemical Hydrogeology (Domenico PA, Schwartz FW, 2nd edition, 1998, ISBN 0-471-59762-7).

Assessment methods and criteria: Examination and report about modelling task are graded in the scale 1-5. Calculus assignments can give 1-3 points for the examination.

Responsible person: Prof. B. Klöve

Language of instruction: Finnish, but the course can also be performed in English – please contact the teacher (B. Klöve) in advance.

488110S Water and wastewater treatment

Credits: 5 credits

Timing: periods 1-2

Objectives: To familiarize the student with the unit operations of water and wastewater treatment used in communities and industry.

Learning outcomes: After the course, student knows basic water and waste water process used in communities and in industry and knows how they works. Student can choose processes for different kind of water and waste water and can do also dimensioning of those processes.

Contents: Biological, chemical and mechanical treatment methods, design practise and control of water and wastewater treatment. Handling, utilization and final displacement of waste water sludge. Wastewater treatment of communities and industry. On-site treatment systems.

Working methods and mode of delivery: Lectures and 2 assignments.

Prerequisites and co-requisites: Introduction to Environmental Engineering or equivalent knowledge about water management. Introduction to Surface Water Modelling is recommended.

Study materials: Handout and other materials delivered in lectures. Soveltuvin osin: RIL 123-1.2003: Vesihuolto I (ISBN 951-758-503-3), RIL 124-2.2004: Vesihuolto II (951-758-438-5), AWWA, ASCE: Water Treatment Plant Design, McGraw-Hill, 2005 (ISBN0-07-141872-5); Metcalf & Eddy: Wastewater Engineering, Treatment and Reuse, 4th edition, McGraw-Hill, London 2003 (ISBN 0-07-112250-8); AWWA (Letterman, R.D. tech. editor): Water Quality and Treatment, McGraw-Hill, London 1999 (ISBN 0-07-001659-3).

Assessment methods and criteria: Examination and assignments.

Responsible person: Lab. Engineer J. Sallanko

Language of instruction: English

488113S Introduction to surface water quality modelling

Credits: 5,0 credits

Timing: periods 2-3. Lectures are given every second years (even autumn periods).

Objectives: To assess the fate of detrimental elements in rivers and lakes using mathematical modeling.

Learning outcomes: The student knows the main transport mechanisms and will be able to model water quality in lakes and streams. The students will be able to use Matlab in environmental analysis, modeling and programming.

Contents: Introduction to modelling in water resources planning, environmental hydraulics, open channel flow, lake hydraulics, processes and water quality, dimensional analysis, hydraulic experiments, transport of conservative and reactive solutes in rivers. Modelling with ordinary differential equations, fully mixed systems, analytical and numerical methods for surface water modelling. Parameter estimation and uncertainty. Tracer tests and measurements systems.

Working methods and mode of delivery: Lectures, exercises and modelling with Matlab.

Prerequisites and co-requisites: Hydrological Processes and basic university level knowledge of mathematics and physics.

Study materials: Surface Water Quality Modelling (Chapra S, 1996, ISBN 0-0701-1-364-5). Fluvial Hydraulics: Flow and Transport Processes in Channels of Simple Geometry. (Walter HG, 1998, ISBN 0-0471-97714-4). Environmental Hydraulics of Open Channel Flows (Chanson H, 2004, ISBN 0-7506-6165-8). Handout and other materials delivered in lectures.

Assessment methods and criteria: Report about exercises (grade 1-5), examination (pass/fail).

Responsible person: University Lecturer A-K. Ronkanen

Language of instruction: English

488117S Water resources management

Credits: 5 credits

Timing: periods 1-2, Lectures are given every second years.

Objectives: To introduce design concepts and principles that must be taken into account in planning of sustainable use of water resources.

Learning outcomes: To understand different processes, principles and mathematical methods used to manage water resources.

Contents: Different water uses and interests, hydropower, hydraulic structures, irrigation and drainage, flood control, modelling, optimization and simulation

Working methods and mode of delivery: Lectures, design and modelling tasks.

Prerequisites and co-requisites: Hydrological Processes.

Study materials: Lecture notes and other material and literature given in lectures.

Assessment methods and criteria: Assignments (grade 1-5).

Responsible person: Prof. B. Klöve and A. T. Haghighi

Language of instruction: English/Finnish

488118S (Laboratory exercises and field measurements in environmental engineering)
Ympäristötekniikan laboratorio- ja kenttäkurssi

Credits: 10 op

Timing: Periods 1-6

Objectives: To familiarise the student with laboratory and field measurement techniques in environmental engineering, and to improve student's comprehension to apply techniques and methods in practice.

Learning outcomes: The student can determine physical properties of soil, understand the basic of fluid flow and hydraulics in practices and know how to design essential treatment operation in the field of water treatment. The student also will be able to observe and measure phenomena and report on the observations in a systematic manner.

Contents: Physical properties of soil, basic phenomena in hydraulics (pipe flow, water discharge from a tank, open channel flow), essential operation in water treatment (sizing of aerator, control of pH, settling processes, Jar-test), transport processes of harmful substances. Quality and safety of field measurements in environmental engineering. Planning of sampling and handling the results with statistical methods. Soil and water sampling with different sampling methods. Follow-up measurements.

Working methods and mode of delivery: Laboratory and field exercises.

Study materials: Announced during the course.

Assessment methods and criteria: Report results from laboratory and field exercises.

Responsible person: A. T. Haghighi

Language of instruction: Finnish or English

488202S Production and use of energy

Credits: 3 cr

Timing: Implementation in 1st period.

Objective: To provide the student with the basics of energy supply, use and equipment in Finnish communities and industrial plants. The student will know energy production, transfer, consumption and market structure in Finland. He/she will also know the distribution, adequacy and environmental issues of energy resources

Learning outcomes: The student is able to explain different methods and techniques to generate electricity and heat. He/she is able to explain steam power plant operating principles and is able to compare operation of different kinds of steam power plants. The student is able to explain the environmental impacts of energy production and is able compare the environmental impacts of different ways of producing energy. He/she is able to explain how the electricity markets work. The student is also able to explain the adequacy of energy reserves.

Contents: Structure of energy production and consumption. Systems for electric transportation, storing and distribution. Distribution and adequacy of energy resources. Effects of environment contracts on the use of energy resources. Environmental comparison of different energy production methods and fuels. Energy markets. Development views of energy technology.

Working methods and mode of delivery: Lectures

Prerequisites and co-requisites: The courses 477011P Introduction to Process Engineering and 488011P Introduction to Environmental Engineering recommended beforehand.

Study materials: Materials in the Optima environment.

Assessment methods and criteria: Written final exam

Responsible person: University researcher Mika Huuhtanen

Language of instruction: English

488203S Industrial ecology

Credits: 5 cr

Timing: Implementation in 2nd period.

Objective: To familiarize the student with the major concepts of industrial ecology and clarify the role of technology towards sustainable development.

Learning outcomes: The student will be able to use the tools of industrial ecology and apply them to industrial activity. The student can also analyze the interaction of industrial, natural and socio-economic systems and able to judiciously suggest changes to industrial practice in order to prevent negative impacts. The student can also analyze the examples of industrial symbioses and eco-industrial parks and able to specify the criteria of success for building eco-industrial parks

Contents: Material and energy flows in economic systems and their environmental impacts. Physical, biological and societal framework of industrial ecology. Industrial metabolism, corporate industrial ecology, eco-efficiency, dematerialization. Tools of industrial ecology, such as life-cycle assessment, design for the environment, green chemistry and engineering. Systems-level industrial ecology, industrial symbioses, eco-industrial parks.

Working methods and mode of delivery: Lectures. Compulsory exercise work.

Study materials: Lecture notes; Graedel T.E & Allenby B.R.: Industrial Ecology. New Jersey: Prentice Hall, 2003.

Assessment methods and criteria: Exercise assignments and written final exam

Responsible person: University researcher Mika Huuhtanen (docent Eva Pongracz)

Language of instruction: English

488204S Air pollution control engineering

Credits: 5,0 cr

Timing: Implementation in 3rd period.

Objective: To familiarise the student with the effects of air pollution, industrial emissions to air and the control. Legislation of air pollution.

Learning outcomes: The student is able to explain what kind of air emissions result from certain industries and power plants and can explain their environmental impacts. The student is able to explain the common air pollution control systems for different emissions (SO2, NOx, VOC, CO2, dust) and is able to dimension air pollution cleaning devices. He/she is able to describe how air emissions are measured. The student is able to describe the main laws related to air emission control.

Contents: Effects of pollution on the atmosphere. Acid rain. Climate change. Ozone. Effects of pollution on health and buildings. Legislation. Measurement of pollution. Long - range transport and diffusion models. Control of emissions, VOC emissions, SO x emissions, NOX emissions, heavy metals, dioxins, freons.

Prerequisites and co-requisites: The courses 477011P Introduction to Process Engineering, 488011P Introduction to Environmental Engineering and 780109P Basic Principles in Chemistry recommended beforehand

Working methods and mode of delivery: Lectures. Exercises

Study materials: Materials in the Optima environment. de Nevers; N.: Air Pollution Control Engineering. 2nd ed. McCraw-Hill 2000. 586 pp.

Additional literature: Singh, H. B.: Composition, Chemistry, and Climate of the Atmosphere. New York 1995. 527 pp.; Bretschneider, B. & Kurfurst, J.: Air Pollution Control Technology. Elsevier, Amsterdam 1987. 296 pp.; Hester, R. E. & Harrison, R. M.: Volatile Organic Compound in the Atmosphere. Issues in Environmental Science and Technology. Vol. 4. Bath 1995; Hester,

R. E. & Harrison, R. M.: Waste Incineration and the Environment. Issues in Environmental Science and Technology. Vol 4. Bath 1995.

Assessment methods and criteria: Written final exam

Responsible person: University researcher Mika Huuhtanen

Language of instruction: English

488205S Environmental load of process industry

Credits: 4 cr

Timing: Implementation in 6th period.

Objective: To familiarise the student with the environmental impacts in process industry such as air pollution, waste water and solid waste in greater detail. The student will also determine the environmental leadership in an industrial plant.

Learning outcomes: The student is able to identify the essential features of the environmental load in wood processing, chemical and metallurgical industry. He/she is able to explain the type, quality, quantity and source of emissions. The student is able to apply the main emission control systems and techniques in different industrial sectors. He/she has the skills to apply BAT-techniques in emission control. The student is able to explain the environmental management system of an industrial plant and is able to apply it to an industrial plant.

Contents: Effluents: types, quality, quantity, sources. Unit operations in managing effluents, comprehensive effluent treatment. Environmental management systems, environmental licences, environmental reporting and BAT.

Prerequisites: The courses 477011P Introduction to Process Engineering, 488011P Introduction to Environmental Engineering, 488204S Air Pollution Control Engineering and 488110S Water and Wastewater Treatment recommended beforehand.

Working methods and Mode of delivery: Lectures

Study materials: Material represented in lectures and in the Optima environment.

Assessment methods and criteria: Written final exam

Responsible person: University researcher Mika Huuhtanen

Language of instruction: English

488400A Orientation to the BEE studies

Credits: 1 cr

Timing: Implementation in 1st period

Objective: The student will learn how studies are conducted in the BEE programme. He/she will be familiar with the University of Oulu, the Faculty of Technology and the Department of Process and Environmental Engineering, as well as the structure of the BEE Master's Degree Programme.

Learning outcomes: After the orientation, the student is able to recognize his/her own study environment and can make use of the student services of the university. He/she will be able to draft an individual study plan together with the programme Study Advisor The student can describe he/she is also able to use the facilities of academic libraries. He/she will be able to access the tools needed for their studies.

Contents: Introduction to studies, overview of the services offered by the university, student organizations, (e.g. academic sports services, student health services). Introduction to the University, Faculty and Department in relation to the BEE studies. Introduction to the methods of studying and to the skills in gaining the tools needed for planning of the studies. Overview of library, Optima, etc. services. Other issues based on the needs of the individual students.

Working methods and mode of delivery: Lectures and exercises; 1. Orientation Days for all new international students organized by the University of Oulu, containing an one day by the Department.. 2. Orientation to the BEE master's degree programme during period 1. 3. Participation to student tutoring during the autumn term. 4. Planning of PSP (personal study plan) and ratification of the study orientation.

Study materials: Will be delivered on need-basis.

Assessment methods and criteria: Active participation.

Responsible person: BEE Study Advisor Marita Puikkonen, and BEE Student Tutor

Language of instruction: English.

488401A Introduction to the environmental and socio-economical issues of the Barents region

Credits: 2 cr

Timing: Implementation in 1st-2nd period

Objective: This course provides an introduction to the Barents region

Learning outcomes: The student will be able to describe the main environmental and socio-economic issues of the Barents region, including its history and culture, and evaluate those issues against the respective issues in his or her country of origin.

Contents: History of the international cooperation between the areas along the coast of the Barents Sea, introduction to the environmental profile of the region, industry and infrastructure, people, livelihoods, cultures, health in the Barents Region

Working methods and mode of delivery: Lectures, discussions, visits, learning diary

Study materials: Material provided during the course.

Assessment methods and criteria: Participation to the lectures, portfolio exam

Responsible person: BEE Student advisor Marita Puikkonen

Language of instruction: English

488402A Sustainable development

Credits: 3 cr

Timing: Implementation in 3rd period.

Objective: This course aims to provide the students an multidisciplinary understanding of the concepts of sustainable development.

Learning outcomes: After completing this course the student is able to explain the multi-disciplinary nature and the concepts of sustainability and to clarify the patterns of resource use and the limits of the carrying capacity of natural systems; and to outline the future perspectives on the prosperity of social and economic systems.

Contents: Multidisciplinary, intensive and interactive course with pre-course and post-course assignments. Presentations on (e.g.) the principles of sustainable development; environmental justice (human rights, minority rights); economic development and sustainability (poverty and equity); social development and culture; corporate sustainability or corporate social responsibility

Working methods and mode of delivery: Lectures, case studies, negotiation simulations, group projects.

Study materials: Materials are provided during the course

Assessment methods and criteria: Course evaluation will be based on activity during the seminar and post-course assignment.

Responsible person: M.Sc. (Tech) Hanna Myllykoski or N.N.

Language of instruction: English

488404A Global change

Credits: 5 cr

Timing: Implementation in 1st-2nd period

Objective: This course aims to introduce and describe the basic concepts in global change.

Learning outcomes: After completing this course the student will be able to describe the concept of global change, and to critically evaluate information available on global change

Contents: The basic concepts in global change: Overview of global change past, present and future perspectives; Method and tools for assessment, scenarios of future change; Overview of some climate change evidences such as global warming, sea level rising, melting glaciers, greenhouse gases, acid raining, ozone hole and so on; Evaluating the global change reasons (natural and human reasons); Evaluating the global change effect on water resource, health, aquatic ecosystems and their goods and services; Global change adaptation in context of sustainable development.

Working methods and mode of delivery: Classroom discussions, student group work, extra literature survey, two reports, two presentations; learning diary

Study materials: Sources of material provided during the course.

Assessment methods and criteria: Assessment is based on the performance of the different assignments listed before, grades 1-5.

Responsible person: University teacher Ali Torabi Haghighi or N.N.

Language of instruction: English

488405S Environmental issues in the Barents region

Credits: 5 cr

Timing: Implementation in 6th period.

Objective: This course aims to provide the student a comprehensive understanding of the environmental landscape of the Barents region, the impacts of past activities, and projections of future economic and social development.

Learning outcomes: After completing this course the students will be able to describe the the environmental landscape of the Barents region, the impacts of past activities, and projections of future economic and social development.

Contents: Northern land-use, Diversity of the northern environment, Land-use and socio-economical changes, Sustainable use of northern resources (forest resources, minerals, Barents Sea resources), Global change in the north, Industry and pollution (prevention and remediation), Socio-economic issues (health, indigenous cultures, languages).

Working methods and mode of delivery: Contact teaching, field-trip and course assignments. Location: Oulanka Research Station, Kuusamo Finland.

Prerequisites and co-requisites: This course is only targeted to the BEE/CP-, BEE/WE-, and BEE/SE- or DPEE/SE-orientation students.

Study materials: Material provided during and prior to the course.

Assessment methods and criteria: Participation to the field trip, performing the given assignments.

Responsible person: D.Sc. (Tech.) Eva Pongrácz

Language of instruction: English

488406A Introduction to environmental science

Credits: 5 cr

Timing: Implementation in 4th period

Objective: The aim of the course is to familiarize the student with the principles of environmental science.

Learning outcomes: The student is able to define the basic concepts of environmental ecology. He/she has knowledge about the state of environment and is able to explain the essential environmental problems and the main effects of pollution. In addition, the student knows some solutions to the environmental problems and is aware about ethical thinking in environmental engineering.

Contents: Principles of environmental ecology. Roots of environmental problems. Global air pollution: ozone depletion, acid deposition, global warming and climate change. Water pollution, eutrophication, overexploitation of ground and surface water. Main effects of pollution and other stresses. Non-renewable and renewable energy. Energy conservation and efficiency. Hazardous and solid waste problem. Principles of toxicology and risk assessment. Environmental ethics.

Working methods and Mode of delivery: This course is performed simultaneously within another course, 488201A Environmental Ecology; Self-study (book reading) and e-learning tasks in the Optima virtual learning environment, and exam.

Study materials: Materials in the Optima environment. Book Chiras D. Environmental Science: Creating a Sustainable Future, New York, Jones and Bartlett Publishers, 2001, for self-study reading.

Assessment methods and criteria: Self-study (book reading) and e-learning tasks in the Optima virtual learning environment

Responsible person: Prof. Riitta Keiski and Virpi Väisänen

Language of instruction: English

488201A Environmental ecology

Credits: 5 cr

Timing: Implementation 4th and 5th period

Objective: The objective of the course is to provide a basic understanding of environmental ecology.

Learning outcomes: The student is able to define the basic concepts of environmental ecology. He/she has knowledge about the state of the environment and is able to explain the essential environmental problems and the main effects of pollution. In addition, the student knows some solutions to environmental problems and is aware of ethical thinking in environmental engineering. The student also has basic knowledge about toxicology and epidemiology.

Contents: Principles of environmental ecology. Roots of environmental problems. Global air pollution: ozone depletion, acid deposition, global warming and climate change. Water pollution, eutrophication, overexploitation of ground and surface water. Main effects of pollution and other stresses. Non-renewable and renewable energy. Energy conservation and efficiency. Hazardous and solid waste problem. Principles of toxicology, epidemiology, and risk assessment. Environmental ethics.

Working methods and mode of delivery: E-learning in the Optima learning environment.

Study material: Chiras D.: Environmental Science: Creating a Sustainable Future. New York, Jones and Bartlett Publishers, 2001.

Prerequisites and co-requisites: The courses 477011P Introduction to Process Engineering and 488011P Introduction to Environmental Engineering recommended beforehand

Study materials: Materials in the Optima environment.

Assessment methods and criteria: Exercises and exam

Responsible teacher: Assistant Virpi Väisänen

Language of instruction: English.

555321S Risk Management

Credits: 3 cr

Timing: Periods 1-3

Objective and learning outcomes: The course familiarizes a student with the overall concept of risk management. During the course we cover the classification of risks in business and the different methods of risk management. Learning outcomes: After completing the course student knows the key concepts of risk and risk management and can explain these. The student can describe risk classifications and can explain the importance of the risk management to organisations. The student can analyse business risks from new point of view and can produce improvement proposals based on the risk analysis. After the course the student can take part in the organisational development in a role of an expert in the area of risk management.

Contents: Theoretical definition of risks. Risks in entrepreneurship and their classifications. Methods of risk management. Tools for corporate risk management.

Working methods and mode of delivery: Lectures and seminar

Study materials: Bernstein P.L. (1996) Against the Gods – The remarkable Story of Risk. John Wiley & Sons Inc., ISBN: 0-471-29563-9; 0-471-12104-5; Lecture materials.

Assessment methods and criteria: Exam and/or group work.

Responsible person: Professor Pekka Kess, Department of Industrial Engineering and Management.

Language of instruction: English.

721704P Business Logistics

Credits: 5 cr

Timing: Period B (periods 2-3)

Objective and learning outcomes: The student recognizes how logistics contributes to business competitiveness and is able to specify central planning principles in logistics management. The student can describe interdependencies between logistics activities and can solve basic problems in materials management and inventory control.

Contents: Course topics include logistics trade-offs, logistics service level, transport and inventory management, logistics performance measurement, basic production planning and order scheduling, just-in-time logistics, and green logistics.

Working methods and mode of delivery: Lectures (30 h), including basic calculations and exercises in classes.

Study materials: Jonsson, P. (2008), Logistics and Supply Chain Management, McGraw-Hill, and supplementary study material in OPTIMA. You can check the availability of the book here.

Assessment methods and criteria: Exam (course book, lectures, basic calculation problems), grades 1-5.

Responsible person: Professor Jari Juga, of Economics and Business Administration (Oulu Business School).

Other information: Please note the number of participants to this course is restricted. Contact the teacher (J. Juga) in advance to be accepted to participate to the course.

Language of instruction: English.

721236P Principles of Environmental Economics

Credits: 5 cr

Timing: Period C (periods 4-5)

Objective and learning outcomes: Students know and are able to verbally and graphically present the most crucial principles and themes of environmental and resource economics.

Contents: Optimal harvesting models of renewable and non-renewable natural resources, contradiction between economic growth and resource scarcity, policy instruments for controlling pollution abatement, and valuation methodology concerning non-market resources and environmental amenities.

Working methods and mode of delivery: Independent reading of the textbooks. The course can be passed with a literature examination in English. The students wishing to do that should contact the teacher.

Study materials: Tietenberg, T: Environmental Economics and Policy, 4th ed., 2004. You can check the availability of the book here.

Assessment methods and criteria: Literature examination, grades 1-5.

Responsible person: Artti Juutinen and/or Erkki Mäntymaa, Faculty of Economics and Business Administration (Oulu Business School)

Other information: Contact the teachers (Juutinen/Mäntymaa) in advance to be accepted to participate to the course.

Language of instruction: English.

5.2 COURSES BY OR IN THE NARVIK UNIVERSITY COLLEGE, NORWAY

Below you can find the course descriptions for the courses organized by or in the Narvik University College, Norway (Sustainable Energy orientation).

STE6297 (UO Code 488420A) Solar and wind energy

Timing: Autumn semester

Scope: 10 ECTS

Location: Narvik University College, Norway

Responsible person: Svein Arne Munkvold. Instructors (lecturers): Trond Østrem, Matthew Homola, and Timothy Charles Lommasson.

Objective: A basic introduction to qualities and quantities of sustainable wind and solar power. Physical principles of wind and solar energy conversion to useable energy and theoretical limits to efficiency and resource base. Understand how the wind and solar power production characteristics match with the load characteristics and integrate into an electrical power grid.

Learning outcomes, skills and attitudes: The successful student will understand the physical principles for wind and solar energy understand important design criteria for wind and solar energy converters and be able to calculate efficiencies of the two technologies. They will also understand how to evaluate the available resource at a site and be able to calculate an expected production from a site.

Contents: 1. Electrical theory: Networks and Kirchhoffs laws. Capacitors and inductors. Maximum power transfer. The pn-junction. 2. Wind energy: Energy in the wind. Characteristics of wind. Methods of conversion. Limits of conversion efficiency. Wind power conversion and control systems. Design options. Excursion to Nygårdsfjell. Estimating energy resource. Value of wind energy. Integration in electrical systems. Wind generation environmental impacts. 3. Solar energy: Solar physics. Semiconductor materials. The pn-junction and doping. Photovoltaics. Efficiency and fill-factor. The influence of heating and radiation. Power distribution and regulation. PV technologies. Wafer production. Excursion to ScanCell.

Working and assessment methods: Lectures and compulsory exercise done in small groups. Visiting plants and industries.

Study materials: Renewable Energy Resources – Second edition, J. Twidell and T. Weir, Taylor and Francis, 2006**.**

Additional literature: Wind Energy Explained, J.F. Manwell, J.G. McGowan and A.L. Rogers, 2002. Handbook of photovoltaic, Science and Engineering, Wiley 2003.

Prerequisites: Course Introduction to Sustainable Energy.

Examination: Written exam of 5 hours. The Exam will be given with the following content: 1. Electrical theory counting for 20 %; 2. Wind energy counting for 40 %; 3. Solar energy counting for 40 %.

STE6298 (UO Code 488422S) Energy systems in buildings and industry

Timing and scope: Autumn semester, 10 ECTS

Location: Narvik University College, Norway

Responsible person: Bjørn R. Sørensen and Raymond Riise

Objective: To give the student broad competence and understanding of how to achieve improved energy efficiency in buildings and industry.

Learning outcomes, skills and attitudes: The students will achieve good skills and expertise on consumer energy systems to assess and solve real world problems in buildings and industry. The students will gain broad understanding of the importance of energy efficiency. The students will be able to assess and design energy efficient solutions for buildings and industries, and the appurtenant installations. This includes mapping and investigation of the prevailing standard of a building, calculation of the impact from different measures, projecting and implementation of measures, and post evaluation of the gained savings.

Contents: 1. Introduction: The role of energy efficiency in a global perspective. Introduction to energy efficiency. The potential of energy reduction. Indoor climate and energy saving. Energy efficiency and environment. 2. Thermodynamics: Heat conduction, convection and radiation. Thermodynamics of humid air. Thermodynamics of heat exchangers and heat pumps. 3. Energy systems in buildings and industry: Climatic factors. Energy supply to and distribution in buildings. District heating systems. Energy stations in buildings. Energy flexibility. Free energy. Regulations and standards. 4. Buildings: Thermal insulation of external walls, roofs and floors. Heat transfer through windows and glazed areas. The impact from cold bridges. Infiltration and exfiltration. Solar radiation on surfaces and internal heat sources. Dynamic conditions, thermal inertia, time constants. Calculation methods for design power and energy consumption. 5. Technical installations in buildings and industry: Ventilation systems and components. Heating systems and components. Cooling systems and components. Lights and electrical equipment. Automation and control strategies. Operation and maintenance procedures. 6. Low energy and passive house design. 7. Energy efficiency in industrial processes. 8. Economical and environmental evaluation: Calculation methods. 9. Project work

Working and assessment methods: Lectures, exercises and problem solving. Project work. Students will be evaluated based on report from project work (40%) and a final exam (60%)

Study materials: Compendia (in English), notes, lecture notes and exercises. Contents will be given at study start.

Prerequisites: Course Introduction to Sustainable Energy

Examination: Written exam of 4 hours, counting 60 %. The project work is compulsory and must be approved to get access to exam. A joint mark will be given for the 40 % project work.

STE6299 (UO 488422S Bioenergy) Bioenergy systems

Timing and scope: Autumn semester, 10 ECTS

Location: Narvik University College, Norway

Responsible person: Raj Calay and Elisabeth Román

Objective: To give an introduction of microbiology in general and also how microbial activity gives end-products for bioenergy use; to introduce how different bioenergy sources can be transferred into useful energy for stationary and transport applications; to provide theoretical analytical understanding of biomass conversion technology to biofuels.

Learning outcomes, skills and attitudes: The successful student will have an overview of: Bio-energy conversion and actual technologies; How biomass and waste can be transferred into bio-fuels; Knowledge of utilising biomass as renewable energy sources and reduce material waste and emissions; Knowledge to present a technical case for the use of a selected source of energy at a particular location and application.

Contents: Introduction to organic chemistry and biochemistry within microbial degradation; Organic sources from wastes and anaerobic microbial degradation; Process technology and case-studies for producing methane from wastes and sludge; Production of gaseous and liquid fuels from biomass; Conversion efficiency; Types and principles of biomass conversions; Utilisation of biomass for electricity generation and production of fuels; Use of bio fuels in transport: combustion in IC engines, emissions; Application of CHP systems for the provision of heating, cooling and electric power; Environmental benefits and impacts; Fuel cells: Definition and principles of operation, losses and efficiency; Fuel cell technologies and applications, stationery and transport.

Working and assessment methods: Lectures and compulsory exercises done in small groups. A visit to bio-energy plants in Trondheim is planned. Project work. Written Exam.

Study materials: Godfrey Boyle: Renewable Energy, 2nd Edition, Oxford University Press in association with the Open University. John Pitchel: Waste Management Practices. Municipal, hazardous and industrial. Taylor and Francis Informa. Wall, Harwood and Demain: Bioenergy. ASM Press Washington , D C. Textbook within fuel cells – not decided yet. The lectures will make compendia with articles.

Additional literature: Brock. Biology of Microorganisms. Twelfth edition. Madigan, Martinko, Dunlap and Clark. Pearson international Edition**.** Kanti L. Shah: Basics of Solid and Hazardous Waste Management technology. Prentice Hll. International Energy Agency: Energy Sector Methane Recovery and Use. The importance of Policy.

Prerequisites: Course Introduction to Sustainable Energy.

Examination: Projects: 1. Microbiology and anaerobic digestion. Counting for 10 %. 2. Conversion efficiency. Types and principles of biomass conversions. Counting 10 %. 3. Utilisation of biomass as fuels in transport: combustion in IC engines. Emissions. Counting 20 %. 4. Written exam of 4 hours. Counting 60 %. The project work is compulsory and must be approved to get access to exam. A joint mark will be given for the 40 % project work. Group size for project work is maximum three students.

STE6300 (UO Code 488410A) Introduction to sustainable energy

Timing and scope: Spring Semester (first year of the Master's programme), 10 ECTS

Location: Narvik University College, Norway and University of Oulu Finland

Responsible person: Elisabeth Román (as responsible study coordinator SE-programme)

Learning outcomes, skills and attitudes: To give an introduction to the most common sustainable energy sources, production forms and distribution methods, and discuss the environmental opportunities, benefits and consequences of utilizing such energy. The successful student will understand the basic physical principles of operation, capacity, growth rates and limitations of the main sources of renewable energy.

Contents:

1. Introduction

a) The science of energy
b) Sources of energy
c) The importance of renewable energy for the development of society
d) Renewable energy flows (forms, quality, planetary energy balance
e) The threat of the green house effect and global climate change
f) The Kyoto Convention
g) Global energy policies
h) National and EU legislation

2. Renewable Energy sources

a) Biomass and bio fuels
b) Solar
c) Wind

3. Market and infrastructure

a) Nordic cooperation
b) The Nordic electric power system
c) The electrical characteristics of the Nordic electric power system
d) Transmission system operators

5. Energy and use

a) Buildings and industry
b) Transport
c) Energy efficiency
d) Energy management

Working and assessment methods: Teaching, advising, project work, work in groups,

Study materials: Godfrey Boyle: Renewable Energy, 2nd Edition, Oxford University Press in association with the Open University. The lecturers will also provide Power point presentations from all lecturers and actual websites.

Prerequisites: Bachelor education

Examination: Written exam of 4 hours

488423S Project work (Pre-master work)

Note: This course description is taken from the UO/DPEE Study Guide 2011-2012 and is therefore not consistent with the other descriptions in this paragraph!

Timing and credits: Implementation in autumn term at the Narvik University College, Norway, 10 cr

Objective: Give the student experience of solving real world scientific problems related to sustainable energy in cold climate areas. Independent problem solving is essential in this course.

Learning outcomes: The specific learning outcome depends on the subject chosen for the project work. The student will have a chance to choose the field that has most interest. The general outcome is that the student will learn how to carry through a real world project and gain experience of scientific work within the energy field. The student will gain insight to the relevant initiatives, instruments and measures required for sustainable energy production, distribution and/or end use.

Contents: 1) Project development: Define the project frames and main goals. Describe the scientific work. Form a project description. Describe methods and resources. Describe the

activities. Plan for propulsion and budget. Literature reviews. 2) Collect and review the state-of-the-art literature on the relevant subjects: Summarize the findings from literature. Adjust the angle of further work. 3) Carry out investigations and/or experiments 4) Analysis and discussion of the problems 5) Thesis / report / presentation.

Working methods and mode of delivery: Personal supervision for each student;

Prerequisites and co-requisites: Preceding courses in the Sustainable Energy orientation study programme must be completed (488410A, 488420S, 488421S, 488422S, and the other previous courses in the Sustainable Energy orientation study programme).

Study materials: Variable, dependent on chosen subject

Assessment methods and criteria: Students will be evaluated based on a final report and presentation.

Responsible person: Prof. Bjørn R. Sørensen. Instructors (supervisors): Bjørn R. Sørensen, Raymond Riise, Elisabeth Roman, Matthew Homola, Svein Arne Munkvold, Trond Østrem, Svein Ove Hareide; Narvik University College, Norway.

Language of instruction: English

SHO6268 Diploma thesis sustainable energy (Master's thesis)

Timing and scope: Spring Semester (second year of the Master's programme), 30 ECTS

Location: Narvik University College, Norway (or University of Oulu, Finland)

Responsible person: Elisabeth Román (as responsible study coordinator SE-programme)

Instructors (**supervisors):** Bjørn R. Sørensen, Raymond Riise, Elisabeth Román, Raj Calay, Matthew Homola, Svein Arne Munkvold, Trond Østrem, Timothy Charles Lommasson, Per Arne Sundsbø (and supervisors from UO)

Objective: The diploma thesis will give the successful student relevant professional experience of solving real world scientific problems related to sustainable energy in cold climate areas.

Learning outcomes, skills and attitudes: The specific learning outcome depends on the subject chosen for the project work. The student will have an opportunity to choose an area that has most interest. The general outcome is that the student will learn how to carry through a real world project and gain experience of scientific work within the energy field. The Diploma thesis is regarded as an *independent work*, and demands the candidates to assess and analyze problems, and to discuss and select solutions best suited to solve the problems. Besides giving knowledge of analytical analysis of problems, the Diploma thesis also gives the candidates insight into R & D areas and research methods. The Diploma thesis will better enable the candidate to plan, pursue and follow-up projects. The Diploma thesis will also qualify the student for work within Sustainable Energy industry and also qualify for a possible PhD-programme.

Contents: The content of the Diploma thesis strongly depends on the chosen subject. The following thus gives the outline or general principles of any Diploma thesis. The Diploma thesis shall contain elements of scientific work: 1. Project development and definition: Define the project frames and main goals. Describe the scientific work. Form a project description and – plan. Describe scientific methods and resources. Describe the activities. Plan for propulsion and budget; 2. Literature reviews: Collect and review the state-of-the-art literature on the relevant subjects. Summarize the findings from literature. Adjust the angle of further work; 3. Carry out investigations and/or experiments; 4. Analysis and discussion of the problems; 5. Develop solutions; 6. Final diploma thesis delivery; 7. Presentation and self evaluation.

Working and assessment methods, study materials. Evaluation: Personal supervision of each student. Students will be evaluated based on a final report and presentation. Study materials dependent on chosen subject. A mark will be given on basis of the final report and the presentation.

Prerequisites: Preceding courses in the SE study programme must be completed.