Master's Degree Programme (BCBU)
in Environmental Engineering

BEE

STUDY GUIDE 2012 – 2014

Department of Process and Environmental Engineering
University of Oulu, Finland

BEE Study Guides 2009-2014
Eds. Ylä-Mella, J. 2009, 2010 & Puikkonen, M. 2010, 2011, 2012
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1 MASTER'S DEGREE PROGRAMME (BCBU) IN ENVIRONMENTAL ENGINEERING

The Environmental Engineering Master's Degree Programme BEE, officially called *Master's Degree Programme (BCBU) in Environmental Engineering*, is a two-year programme implemented in the University of Oulu Finland. The graduating BEE students will be awarded a degree of Master of Science in Technology. MDP BEE is one of the Barents Cross Border University (BCBU) master's degree programmes, and was originally developed within the international cooperation with the BCBU universities in the Barents Region (Finland, Norway, Sweden, and Russia). You can read more about the BCBU cooperation in chapter 6.

The BEE MPD is based on environmental engineering plus process and civil engineering. BEE curriculum is multidisciplinary, including subjects ranging from the before-mentioned engineering sciences to sustainable development, ethics and legislation, with some courses specializing to the Barents Region circumstances. The programme takes two years with 120 ECTS [(1)] of studies, and can include an exchange period in one of the participating BCBU universities.

1.1 Study options in the BEE MDP

Currently the main responsibility for the delivery of the BEE programme is on the Department of Process and Environmental Engineering at the Faculty of Technology, University of Oulu, Finland, with two BEE majors, the so-called study options *Clean Production*, and *Water and Environment*, and another related study option, Sustainable Energy, run along the two. Further, in several of the Russian BCBU universities, there are ongoing study options related to the BCBU/BEE programme.

1.1.1 Clean Production / University of Oulu

The Clean Production (CP) study option 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 study option was started in September 2009 at the University of Oulu, and here have been altogether four intakes to the BEE/CP study option so far.

1.1.2 Water and Environment / University of Oulu

The Water and Environment (WE) study option includes studies on protection and restoration of natural water and ground environment, as well as water and soil pollution, water and waste water treatment, and waste technology. The WE study option was started in September 2009 at the University of Oulu, and here have been altogether four intakes to the BEE/CP study option so far.

[1] ECTS, European Credit Transfer System

1.1.3 Sustainable Energy / University of Oulu Finland & Narvik University College Norway

Even if the Sustainable Energy (SE) study option is not actually a true BEE study option, but currently one of the study options in the two national master's degree programmes of the Department of Process and Environmental Engineering, it is described here, since part of the studies in the SE programme have been organized together with a BEE/BCBU partner university Narvik University College in Norway.

The Sustainable Energy (SE) study option answers the need to find green energy solutions, especially for the northern Barents Region environmental conditions. Strong focus is set on hydro, wind, solar and bioenergy technologies, as well as energy efficiency issues in energy production, distribution and end use. The SE study option was started in September 2010 at the University of Oulu Finland, as part of the two national Master's programmes of the Department of Process and Environmental Engineering. The SE studies include one semester long exchange period at the Narvik University College, Norway, or some other foreign university in the area of sustainable energy, e.g., at the Luleå University of Technology, Sweden.

1.1.4 Other study options / Russia

Within the BCBU co-operation, other, Russian master's degree programmes, study options and/or study modules are organized. More information is given at their web pages - see e.g. the Russian universities of the Northern (Arctic) Federal University (NArFU), Murmansk State Technical University (MSTU), and Petrozavodsk State University (PetrSU).

1.2 Student exchange

The BEE MDP can include an exchange period (during the autumn semester of the second study year) at some of the BCBU/BEE partner universities, within their study programmes or other course modules in the area of environmental and or process engineering. In the Clean Production and Water and Environment study options, courses completed during the exchange period can be included in the supplementary module of the CP/WE curriculum respectively. Participation to these courses must always be planned and agreed in advance with the BEE Student Advisor.

In the Sustainable Energy study option the students from the University of Oulu will take the exchange period at the Narvik University College in Norway (or at some other foreign university in the area of sustainable energy), during the autumn semester of the second study year. Possibly also the master's thesis phase of the studies (scheduled to the spring of the second study year) can be taken during the exchange in Norway.

2 STUDENT SERVICES AT UNIVERSITY OF OULU FINLAND

2.1 Oulu University Library and other such student services

The Oulu University Library is divided into many units, of which the most important for BEE students are the units of Course Book Library *Cursus*, the Science Technology Library *Tellus* and the Main Library *Pegasus*. All these units are located in the UO Linnanmaa campus, see link to the Linnanmaa Campus Map [(2)]. More specific information about Oulu University Library units, opening hours and services is available at link to Oulu University Library [(3)].

The other international students' services can be found at the Studying pages [(4)] of the university. New international students also receive orientation materials, guide books etc. when they arrive, containing lots of information about the students' services at UO.

2.2 Faculty of Technology and its student services

The BEE MDP is one of the three [(5)] international master's degree programmes organised at the Faculty of Technology, which is the largest of the six faculties of the University of Oulu. The Faculty 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 are located at the University of Oulu Linnanmaa campus (see link to a map above under chapter 2.1).

The faculty administration is managed by Dean and two (vice) Deans (one for research and one for education), the Faculty Council, and two committees, Committee for Education and Committee for Research. The Faculty also has a Selection Committee common for all admissions in the faculty. Further, the faculty has Administrative Manager and Student Affairs Manager officials.

Degrees that can be awarded by the Faculty of Technology are Bachelor of Science in Technology, Master of Science in Technology and Master of Science in Architecture; and further, Licentiate of Science in Technology; and Doctor of Science in Technology (or Doctor of Science) as respective postgraduate degrees.

2.2.1 How to find us

Faculty home pages:	http://www.ttk.oulu.fi/English/
Faculty office:	Location at Linnanmaa Campus in room YT103, entrance: door R
Telephone:	+358 2 9448 2001 or +358 2 9448 2002
Office hours:	9:00-14:00

[2] Linnanmaa Campus map, see http://www.oulu.fi/kartat/Linnanmaa_2010_English.pdf
[3] University of Oulu Library, see http://www.kirjasto.oulu.fi/index.php?id=509
[4] Studying at the UO, see http://www.oulu.fi/english/studying
[5] Note: Of the three MDPs at the Faculty of Technology, only BEE belongs to BCBU

2.2.2 Faculty administrative personnel

Dean of the Faculty: Professor Mr. Kauko Leiviskä
Dean for Education: Professor Mrs. Helka-Liisa Hentilä
Dean for Research: Professor Mr. Harri Haapasalo
Administrative Manager: Mrs. Laila Kuhalampi
Student Affairs Manager: Mrs. Sirpa Nelo
Student Affairs Secretaries:

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. The department conducts research and education in engineering sciences, along all of the focus areas of the University: in biotechnology and molecular medicine, information technology, 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. DPEE has long research co-operation with NorTech Oulu [(6)] at the Thule Institute within the environment-related research subjects in the Environmental Technology Development Programme.

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 for teaching, the Department 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. DPEE is the only such unit winning this prize three times consecutively.

The research and education activities of DPEE are divided into eight laboratories, lead by 10 professors: Bioprocess Engineering Laboratory (prof. Heikki Ojamo), Chemical Process Engineering Laboratory (prof. Juha Tanskanen), Control Engineering Laboratory (prof. Kauko Leiviskä), Fibre and Particle Engineering Laboratory (prof. Jouko Niinimäki), Mass and Heat Transfer Process Laboratory, including the Industrial Environmental Engineering unit (prof. Riitta Keiski), Laboratory of Process Metallurgy (prof. Timo Fabritius), Systems Engineering Laboratory (prof. Enso Ikonen), Water Resources and Environmental Engineering (prof. Björn Klöve and prof. Kauko Kujala). From autumn 2012 the department will have professorship for Mineral Processing within the department together with the Oulu Mining School research centre (OMS). OMS is lead by research professor Leena Yliniemi. The department has also other research centres, e.g. CASR [(7)]. In addition to the above-mentioned laboratories and research centres, DPEE has administrative and educational offices.

DPEE is administrated by Head of the Department and Vice Head of the Department and a Steering Group. Further, the department has administrative personnel for the implementation of the DPEE affairs. DPEE also has a Study Programme Committee, responsible for development of the DPEE bachelor and master level education (also BEE), and, there is a workgroup Pakki for handling student feedback on the department's education, studies and courses.

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6 NorTech Oulu at the Thule Institute, see http://nortech.oulu.fi/eng/index.html, and the Environmental Technology Development Programme, see http://nortech.oulu.fi/ETEP/index.html

7 DPEE laboratories, see http://pyo.oulu.fi/index.php?62; Oulu Mining School, see http://www.oulumining.fi/briefly-in-english.html; CASR, Centre for Advanced Steel Research, see http://www.oulu.fi/casr/

PhD-level studies [8] 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 Research Committee of the department.

2.3.1 How to find us

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

DPEE webpages:	http://pyo.oulu.fi/index.php?id=1&lang_id=1 (situation on June 27th, 2012)
Department office:	Linnanmaa, rooms PR113 (administrative issues) PR114 (educational issues) PR115 (department meeting room)
Telephone:	+358 2 9448 2300
Head of the Department:	Mr. Jukka Hiltunen (responsible for education)
Vice Head:	Prof. Mrs. Riitta Keiski (responsible for research)
Student Counsellors:	Mrs. Marita Puikkonen (BEE study advisor, OMS study coordinator) Mrs. Saara Luhtaanmäki (study programmes of process engineering and environmental engineering) Mrs. Katri Kosonen (student exchange coordinator)
Administrative secretary:	Mrs. Hannele Timonen

2.3.2 DPEE Student advisors and tutors and student associations

The DPEE student counsellors instruct students in all different issues related to their studies. DPEE has three student counsellors for different groups of students: Mrs. Saara Luhtaanmäki for the Finnish process and environmental engineering bachelor and master level students, Mrs. Katri Kosonen for exchange students and student exchange. For the BEE programme, the counsellor is Student Advisor Mrs. Marita Puikkonen (room PR165, phone +358 2 9448 2309, email marita.puikkonen[ät]oulu.fi). She helps the BEE MPD 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 a student tutor, *Kummi*, a peer student helping new international students in the beginning of their studies and to help them become part of the University academic community. In addition, the peers also help with practical issues like visiting various offices, registering to the university, etc. For the new class BEE'12 students, the student tutor is Mr. Aleksi Niskavaara (email alniskav[ät] mail.student.oulu.fi).

DPEE has two student guilds (student associations), Prosessikilta [9] for the process engineering students, and Ympäristörakentajakilta [10] for environmental engineering students including the BEE students. All students of the University of Oulu belong to OYY [11], the Student Union of the University of Oulu. International degree students can also join the Network of International Students (NISO), which has their webpages in Facebook [12].

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8 From 1.8.2011 all PhD-level studies at UO are coordinated by the University of Oulu Graduate School UniOGS, see more information at http://www.oulu.fi/uniogs/

9 Prosessikilta, see http://www.prosessikilta.fi/index.php?option=com_content&view=article&id=212&Itemid=211

10 Ympäristörakentajakilta, see http://www.ymparistorakentajakilta.net/cms/

11 Student Union of the University of Oulu OYY, see http://www.oyy.fi/en/

12 NISO at Facebook, see https://www.facebook.com/groups/nisoo/

3 STUDYING IN THE BEE PROGRAMME

3.1 Degree programmes of DPEE

Currently there are two national bachelor-level study programmes at DPEE: the Study Programme of Process Engineering and the Study Programme of Environmental Engineering. Respectively, the master-level programmes are the two national programmes Process Engineering and Environmental Engineering (continued from the bachelor-level), and the international BEE MDP in environmental engineering. At the master-level, the studies are implemented as several majors, or study options and specialisations therein. Further, the department co-operates with other UO departments in the implementation of the multidisciplinary Vikebi educational programme Green Chemistry and Bioproduction [(13)], which is later planned to start as an international master's degree programme.

3.2 Personal Study Plan

From the start of their studies, all students in the BEE programme will follow their Personal Study Plans (PSP) [(14)] which are based on the official curriculum of their study option, i.e. on the structure of the degree programme.

PSP is a plan students prepare for themselves that contains the contents, extent, timing semester-vice, and duration of their studies. The PSP is prepared in the beginning of the studies together with the BEE Student Advisor for the entire degree, by using the OodiPSP programme (within the WebOodi system, see more in chapter 3.4.2). The PSP allows students to see their completed and upcoming courses, which helps both students and their advisors to follow the PSP progress. Students should familiarise themselves with their curriculum early on in their studies and think about their studies in the long term, as long-term thinking stresses the relevance of the overall study programme and helps students realize the time required to complete a degree.

The PSP is updated together with the Advisor regularly. 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.

Models for the Personal Study Plans for each of the two study options are available at the BEE page 'For current students', see:

- For study option 'Clean Production'
  http://bee.oulu.fi/BEE_CP_Study_plan_model_2012-2014.pdf (the address will change)
- For study option 'Water and Environment'
  http://bee.oulu.fi/BEE_WE_ Study_Plan_Model _2012-2014.pdf (the address will change)

[13] Vikebi Green Chemistry and Bioproduction educational programme, see http://www.oulu.fi/vikebi/english.html
[14] See more about the PSP at: http://www.oulu.fi/english/studying/supporting-your-studies/personal-study-plan-psp
See also the OodiPSP Guide for students at: http://www.oulu.fi/oodi/Ohjeet/OodiPSP_Guide_for_students.pdf

3.3 Study schedules and the structure of the academic year

In the Faculty of Technology and in the Department of Process and Environmental Engineering, the academic year is divided into three semesters: autumn semester (September-December), spring semester (January-April), and an additional summer semester (May-August, reserved mainly for advanced practical training). Further, the first two semesters are divided into three study periods (periods 1-3 on autumn semester, periods 4-6 on spring semester). Courses are offered period-vice, i.e. they continue for one or more consecutive periods.

The students will plan their own, specific course schedules for the study year together with their study advisor, by first writing out electronically their actual personal study plans, PSPs in WebOodi (OodiPSP), and then, moving this information to the schedule programme Lukkari [(15)]. Lukkari gives the specific course schedules, their locations and responsible teachers for the whole study year. In these Lukkari schedules, the given *lesson times* imply (despite their shown phrases) to hours beginning from "fifteen past", referring to the so called "academic quarter". E.g. if the course is scheduled to take place at hours 8:00-9:00 and 9:00-10:00, this actually means that the course has its lessons at 8:15 to 9:45 (cf. one lesson hour is usually considered to be 45 min long). Any exceptions to the schedules will be agreed at the lessons with the teacher and are would be given within the respective course information.

The dates for the study periods of the academic study year 2012-2013 are given in the table below. The dates for periods for the academic year 2013-2014 will be announced later, but will be quite similar to the below-mentioned. Please note that the given dates refer to the courses arranged by the Faculty of Technology and DPEE, and courses given by other UO departments or faculties are taught according to timetables followed by those.

Academic calendar, study year 2012-2013

1. *Autumn term 2012 in the Faculty of Technology / DPEE*

   Study period 1: September 3 > October 10 (weeks 36-40)
   Study period 2: October 13 > November 18 (weeks 41-45)
   Study period 3: November 21 > December 14 (weeks 46-50)
   Holiday period: December 15, 2012 > January 6, 2013 (weeks 51-1)

2. *Spring term 2013 in the Faculty of Technology / DPEE*

Study period 4:	January 7 > February 8 (weeks 2-6)
Study period 5:	February 11 > March 22 (weeks 7-12)
Study period 6:	March 25 > May 10 (weeks 13-19)
Summer semester:	May 11 > September 1 (weeks 20-35)

[15] Information about the Lukkari study schedule, see http://www.oulu.fi/english/studying/lukkari, and the Lukkari programme https://lukkari.oulu.fi/. Please note that you can only access the actual plans or schedules after you have arrived and have officially registered to the university.

3.4 Courses and their performance

3.4.1 Course codes, names and extents

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 the digits 488 are organised for the different study options of the environmental engineering study programme, and with 477… for process engineering. Code letter "A" (referring to Finnish word *aine*) represents subject studies and "S" for advanced (*syventävä*) studies. For the extents of the courses, ECTS, see the footnote 16 [(16)].

3.4.2 Participation to courses, course materials

The student must enrol to the course to participate, using the electronic WebOodi system (https://weboodi.oulu.fi/oodi/). WebOodi is the register of University of Oulu students and their studies. WebOodi also contains the OodiPSP programme. Course descriptions etc. information can also be found at the WebOodi system. In addition, course information and materials can be found, e.g., in the Optima Learning Environment, https://optima.oulu.fi/, or in the Noppa Study Portal, https://noppa.oulu.fi/noppa/app.

The students can access all these systems after getting their student user accounts (which is also used for email, etc.).

3.4.3 Performance, evaluation and grading of courses

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 a final examination". Also other methods, e.g. seminars or learning portfolios, etc. are implemented. Usually when such other methods are used, the course does not contain final examination. The course performance method is also shown in the course description at WebOodi.

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 are generally arranged on Fridays at from noon to 4 p.m. and last for four hours. Generally, there are two repetitive examinations arranged after this first, so called "course examination". Enrolment to the exams is obligatory. Enrolment must be done at the latest at noon two days before the examination via WebOodi. 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 in the student's own personal schedule (Lukkari).

The course performances, and also that of the Master's Thesis, are evaluated with grades "Failed" or "Accepted", or by numerical grades: For "Passed" with 1-5 (1 = satisfactory, 2 = very satisfactory, 3 = good, 4 = very good, 5 = excellent), and respectively, for "Failed", with 0.

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[16] **ECTS (European Credit Transfer System)**: The workload of studies is expressed in ECTS credits (in Finnish *opintopiste, op*) to ease the comparison of studies organized by different European universities. One ECTS credit equals to approximately 27 hours (26 $^{2}/_{3}$ hours exactly) of student-studying-work. ECTS is a student-centred system, based on the required students' workload to achieve the objectives of a study programme / courses therein, 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.
Refs: http://www.avoinyliopisto.fi/glossary and http://eacea.ec.europa.eu/erasmus_mundus/tools/glossary_en.php

4 THE CURRICULA OF THE BEE MASTER'S PROGRAMME

The major or study option (Clean Production or Water and Environment) 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. The curricula for the two study options are describes in the next chapters. See also chapter 3.2 for personal study plan models of these study options – the model PSPs are based on the curricula.

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, but also beyond. 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 study options

The quadrangular model curriculum structure of the two BEE study options Clean Production (CP) and Water and Environment (WE) is presented in Fig. 1 below. The curriculum for each orientation includes Basic, Advanced and Supplementary Modules and a Master's Thesis. 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.

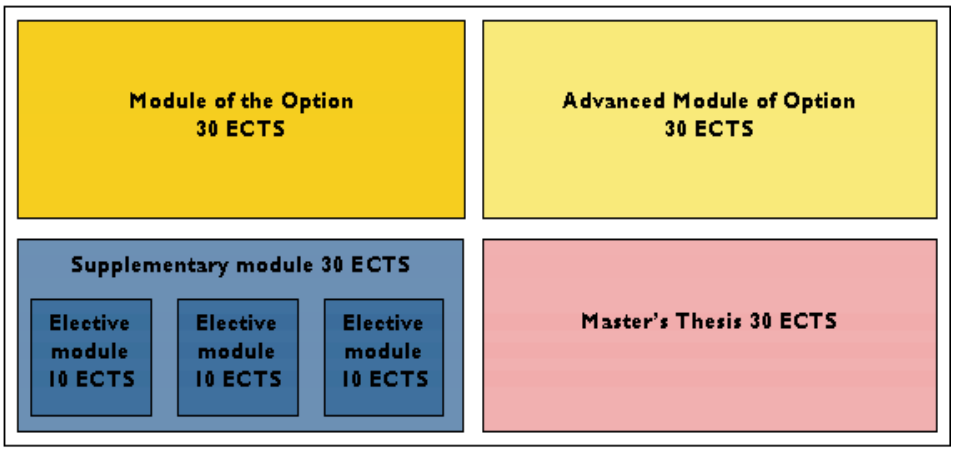

Figure 1 The quadrangular model curriculum structure of the BEE study options Clean Production and Water and Environment

The Basic Module gives the student the basic knowledge of his/her study option, and that knowledge is then further deepened by the Advanced and Supplementary Module courses. The Supplementary Module consists of three elective (optional) submodules, chosen from a total of five different for each orientation. The Master's Thesis work finalizes the studies. In the first study year, the Basic [(17)] Module (on autumn semester) and the Advanced Module (on spring) contain mostly the same courses in both study options. During the second year, the studies are continued with supplementary courses (Supplementary Module, second autumn) and the Master's Thesis (second spring).

4.3 Master's Thesis in the Clean Production and Water and Environment study options

The Master's Thesis project (in Finnish Diplomityö) is an advanced-level study performance of 30 ECTS. The project is planned to be conducted mainly 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 Master's Thesis is evaluated and accepted by the Department of Process and Environmental Engineering.

The Master's thesis project also contains 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 papers scholarly and his/her familiarity with the theories and problems of the thesis. The maturity test must be written without any supporting materials, under supervision.

4.4 Curriculum of the Clean Production study option

4.4.1 Clean Production: Basic Module

Courses of the CP Basic Module are all compulsory for the students of the study option. 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 name*	*ECTS*	*Periods/Year*
488400A	Orientation to the BEE Studies	1.0	1-4 / I
488401A	Introduction to the Environmental and Socio-economical Issues of the Barents Region	2.0	1-2 / I
488402A	Sustainable Development	3.0	3 / I
488012A	Ympäristölainsäädäntö (Environmental Legislation)	5.0	4-5 / I
477307S	Research Methodology	5.0	2-6 / I
488404A	Global Change	5.0	1-2 / I
488201A	Environmental Ecology	5.0	4-5 / I
488203S	Industrial Ecology	5.0	2 / I

[17] Option = study option

4.4.2 Clean Production: Advanced Module

The CP Advanced Module contains both compulsory (*) and optional (elective among each other) studies. 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 Advanced Module 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 name*	*ECTS*	*Periods/Year*
488405S	Environmental Issues in The Barents Region*	5.0*	6 / I
488002S	Advanced Practical Training*	3.0*	Summer / I
477203A	Process Design	5.0	4-5 / I
477041S	Experimental Design	5.0	4 / I
477311S	Advanced Separation Processes	5.0	6 / I
488205S	Environmental Load of Process Industry	4.0	6 / I
477309S	Process and Environmental Catalysis	5.0	2 / I
488104A	Industrial and Municipal Waste Management	5.0	5-6 / I

4.4.3 Clean Production: Supplementary Module

In the Supplementary Module, the CP student will select studies from the different submodules 1-5. All courses are optional (elective among each other). 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 that the courses in the Submodules 4 and 5 are organized by either the Department of Industrial Engineering and Management, or the Faculty of Economics and Business Administration (Oulu Business School) or by the BCBU/BEE partner universities so that their actual scheduling depends upon their specific timetables. The other submodules are organized by DPEE. Further, for the Submodule 5, the student can also choose the courses, based on his/her own interest, e.g. from the other available courses organized by DPEE not mentioned in this curriculum, for example course Research Ethics, etc. The Supplementary Module courses should preferably mostly be performed 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 name*	*ECTS*	*Periods/Year*
Submodule 1 Energy and Environment			
488204S	Air Pollution Control Engineering	5.0	3 / II
488202S	Production and Use of Energy	3.0	1 / II

(table continues)

Code	*Course name*	*ECTS*	*Periods/Year*
Submodule 2 Control of Phenomena			
477306S	Non-ideal Reactors	5.0	3 / II
477305S	Virtausdynamiikka (Flow Dynamics)	5.0	2 / II
Submodule 3 Process Design			
477206S	Advanced Process Design	6.0	5-6 / I (!)
477503S	Simulointi (Simulation)	3.0	3 / II
477209S	Chemical Process Simulation	5.0	2-3 / II
Submodule 4 Economics and Management			
555321S	Risk Management	3.0	1-3 / II
721236A	Principles of Environmental Economics	5.0	4-5 / II
721704A	Business logistics	5.0	2-3 / II
Submodule 5 Elective Courses			
	Courses by or at the BEE/BCBU partner universities	10.0	1-3 / II

4.5 Curriculum of the Water and Environment study option

4.5.1 Water and Environment: Basic Module

Courses of the WE Basic Module are all compulsory for the students of this study option. 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 methods for water and waste water treatment, and can manage the basic practices in the laboratory and field work in environmental engineering.

Code	*Course name*	*ECTS*	*Periods/Year*
488400A	Orientation to the BEE Studies	1.0	1-4 / I
488401A	Introduction to the Environmental and Socio-economical Issues of the Barents Region	2.0	1-2 / I
488402A	Sustainable Development	3.0	3 / I
488012A	Ympäristölainsäädäntö (Environmental Legislation)	5.0	4-5 / I
477307S	Research Methodology	5.0	2-6 / I
488118S	Laboratory Exercises and Field Measurements in Environmental Engineering	10.0	1-6 / I
488110S	Water and Wastewater Treatment	5.0	1-2 / I

4.5.2 Water and Environment: Advanced Module

The WE Advanced Module contains both compulsory and optional (elective among each other) 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 name*	*ECTS*	*Periods/Year*
488405S	Environmental Issues in the Barents Region*	5.0*	6 / I
488002S	Advanced Practical Training*	3.0*	Summer / I
488102A	Hydrologiset prosessit (Hydrological Processes)	5.0	1-6 / I
477041S	Experimental Design	5.0	4 / I
477311S	Advanced Separation Processes	5.0	6 / I
477203A	Process Design	5.0	4-5 / I
488104A	Industrial and Municipal Waste Management	5.0	5-6 / I

4.5.3 Water and Environment: Supplementary Module

In the Supplementary Module, the WE student will select studies from different submodules 4-8. All the courses are optional (elective among each other). 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 also note that the courses in the Submodules 4 and 5 are organized by either the Department of Industrial Engineering and Management, or the Faculty of Economics and Business Administration (Oulu Business School) or by the BCBU/BEE partner universities so that their actual scheduling depends upon their timetables. The other submodules are organized by DPEE. Further, for the Submodule 5, the student can also choose the courses, based on his/her own interest, e.g. from the other available courses organized by DPEE not mentioned in this curriculum, for example course Research Ethics, etc. The Supplementary Module courses should preferably mostly be performed 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 name*	*ECTS*	*Periods/Year*
Submodule 4 Economics and Management			
555321S	Risk Management	3.0	1-3 / II
721236A	Principles of Environmental Economics	5.0	4-5 / II
721704A	Business logistics	5.0	2-3 / II

(table continues)

Code	*Course name*	*ECTS*	*Periods/Year*
Submodule 5 Elective Courses			
	Courses by or at the BEE/BCBU partner universities	10.0	1-3 / II
Submodule 6a Water 1 (available only on odd years, next time 2013)			
488108S	Groundwater Engineering	5.0	1-2 / II
488117S	Water Resources Management	5.0	3-4 / II
488122S	Statistical Methods in Hydrology	5.0	1-2 / II
Submodule 6b Water 2 (available only on even years, next time 2012)			
488103A	Environmental Impact Assessment	5.0	1-3 / II
488113S	Introduction to Surface Water Quality Modelling	5.0	2-3 / II
Submodule 8 Environmental Systems			
488203S	Industrial Ecology	5.0	2 / II
488404A	Global Change	5.0	1-2 / II

5 COURSE DESCRIPTIONS

5.1 Courses in the University of Oulu, Finland

The specific courses belonging to the BEE programme curricula (to the study options CP and WE) are described in WebOodi (see https://weboodi.oulu.fi/oodi/). You can find the same descriptions from the list below (search by codes or names).

In the list, courses are presented in alphabetical order by course names. At the Department of Process and Environmental Engineering there are also several other courses organized in English. You can look for them in the DPEE Study Guide (if the course description is given in English, the language of instruction is English).

488002S ADVANCED PRACTICAL TRAINING

ECTS Credits: 3 cr (for which minimally two months of actual working needed)

Language of instruction: English

Timing: Student works in the summer time (the summer between the first and the second study year of his/her).

Objective: To give a deeper and more detailed conception of the industrial area where the student will possibly work after graduation. Suitable tasks would be, e.g., supervision tasks R&D tasks. Students will find the jobs themselves.

Learning outcomes: During the advanced practical training the student is exposed to his/her working environment from the point of view of his/her studies, and becomes acquainted with possible future jobs or to different assignments in already familiar working environments. The student can identify the problems of the working environment and can solve them. The student can apply theoretical knowledge in practical tasks. The student identifies the tasks appropriate for the Master of Science in Technology at his/her workplace.

Contents: Suitable areas for practical training are, for example, regional environment centers, environmental engineering and consulting offices, water-works, biotechnological and food industry, chemical industry, pulp and paper industry, metallurgical and mining industry, partly electronics and automation industry, and other areas in the private and public sectors.

Working methods and Mode of delivery: Working as employee in a company, university research unit, etc. (during summer), and a seminar (on next autumn) where the student presents his/her working experience (oral presentation).

Target group: Master's degree students

Assessment methods and criteria: Student has to show his/her original references (summer job certificate, indicating the training time period and the duties) and the pre-filled-in application form to the seminar supervisor; in addition to giving the seminar presentation. The supervisor accepts the course performance meeting the set criteria (minimally 2 months working, given presentation, and presented original certificate).

Grading: Verbal scale Passed/Failed.

Responsible person: The supervisor of the seminar (for BEE students, Marita Puikkonen)

Work placements: Yes.

477206S ADVANCED PROCESS DESIGN

ECTS credits: 6 cr

Language of instruction: English

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.

Target group: Master's students in DPEE

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

Recommended optional programme components: Part of Process Design Module

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.

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Responsible person: University lecturer Juha Ahola

477311S ADVANCED SEPARATION PROCESSES

ECTS credits: 5 cr

Language of instruction: English

Timing: Implementation in spring semester during 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.

Mode of delivery: With the lectures the students will familiarize themselves to the latest research publications.

Learning activities and teaching methods: Lectures 30 h, seminar work 25 h.

Target group: Master's degree students of the Department of Process and Environmental Engineering.

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

Recommended optional programme components: This course is proposed to be taken within the Research module.

Study materials: The course literature will be chosen when the course is planned. Latest scientific research articles. *Further literature:* Separation Processes in the Food and Bio-technology Industries, Edited by: Grandison, A.S. & Lewis, M.J. 1996 Woodhead Publishing.

Assessment methods and criteria: Portfolio or written examination and a seminar work including reporting and presentation.

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Professor Riitta Keiski

488204S AIR POLLUTION CONTROL ENGINEERING

ECTS credits: 5 cr

Language of instruction: English

Timing: 3rd period

Objective: To familiarise the student with the effects of air pollution, industrial emissions to air and their control. Air pollution –related legislation.

Learning outcomes: The student is able to explain what kind of air emissions originate 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 (SO_2, NOx, VOC, CO_2, dust) and is able to design air pollution cleaning devices. He/she can describe how air emissions are measured. In addition, 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, nature and buildings. Legislation. Measurement of pollution. Long - range transport and diffusion models. Emission control technologies, VOC emissions, SO_x emissions, NO_X emissions, heavy metals, POPs, HAPs, etc.

Learning activities and teaching methods: Face-to-face teaching

Mode of delivery: Lectures 30h and exercises 10h

Target group: Master's degree students of the Department of Process and Environmental Engineering

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

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

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Satu Ojala

721704A BUSINESS LOGISTICS

ECTS Credits: 5 cr

Language of instruction: English

Timing: Period B of Oulu Business School (corresponding to periods 2-3 of DPEE)

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: Topics include logistics tradeoffs; logistics service level, transport and inventory management, logistics performance, basic production planning and order scheduling, just-in-time logistics, and green logistics.

Learning activities and teaching methods: Lectures (30 h), including basic calculations and exercises in classes.

Recommended or required reading: Jonsson, P. (2008), Logistics and Supply Chain Management, McGraw-Hill, and supplementary study material in OPTIMA. Check availability from here.

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

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Professor of logistics Jari Juga (Oulu Business School)

Other information: The number of students is limited.

477209S CHEMICAL PROCESS SIMULATION

ECTS credits: 5 cr

Language of instruction: English

Timing: Periods 2-3.

Objective: Performing chemical process simulation studies successfully.

Learning outcomes: The student has the ability to convert a process flow diagram into a form compatible with process simulation software. She/he has skills to evaluate realistic process conditions in a typical chemical process. The student can apply proper thermodynamic property models for simulation purposes. She/he can name the advantages and disadvantages of using the sequential modular solving approach in chemical process modelling and simulation. She/he is capable of solving a computer simulation case for a typical chemical process. The student is able to analyze the simulation results with respect to realistic values.

Contents: The architecture of a process simulator. Thermodynamic property models and databanks. Degrees of freedom analysis. Steady-state simulation. Sequential modular, and equation-oriented approach in simulation. Numerical solving methods. Heuristics for chemical process simulation.

Mode of delivery: Lectures, introductory examples and group exercises with process simulation software.

Target group: Master's students in Process Design and Chemical Engineering orientations

Prerequisites and co-requisites: Prerequisite: 477204S Chemical Engineering Thermodynamics or equivalent knowledge.

Study materials: Material distributed on lectures. Additional literature, Turton, R., Bailie, R.C., Whiting, W.B. & Shaeiwitz, J.A.: Analysis, synthesis, and design of chemical processes. 3rd Ed. Prentice Hall. (Parts) ISBN 0-13-512966-4.

Assessment methods and criteria: Group exercise reports and an individual exam.

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Responsible person: University Teacher Jani Kangas

488201A ENVIRONMENTAL ECOLOGY

ECTS credits: 5 cr

Language of instruction: English

Timing: 4th and 5th period

Objective: The student is able to define the basic concepts 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.

Learning activities and teaching methods: E-learning in the Optima learning environment.

Mode of delivery: Distance teaching

Target group: Master's degree students of the Department of Process and Environmental Engineering

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

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

Assessment methods and criteria: Exercises and exam.

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Rauli Koskinen

488103A ENVIRONMENTAL IMPACT ASSESSMENT

ECTS credits: 5-8 cr

Language of instruction: English

Timing: The course unit is held in the autumn semester, during periods 1-4

Learning outcomes: The student will acquire a broad and multidisciplinary and sustainable approach to environmental impact assessment (EIA). The student will know the all steps in EIA process and the different methods used in environmental impact assessment. During the course students develop their working life skills (e.g. writing, communication and presentation skills) and the ability to review environmental problems. Thy also learn how to resolve extensive environmental projects related problems, causes and consequences.

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

Mode of delivery: Face-to-face teaching

Learning activities and teaching methods: The whole course contains lectures (56 h), independent works (assignments and learning diaries, 70 h) and 3 seminars (9 h).

Target group: Master students in the Environmental Engineering study program

Prerequisites and co-requisites: The required prerequisite is the completion of the following course or to have corresponding knowledge prior to enrolling for the course unit: 488011P Introduction to Environmental Engineering

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

Assessment methods and criteria: The course includes six modules, which are evaluated separately (with the scale 1-5). The first module is 3 ECTS credits and it is requisite for next modules. Other modules are 1 ECTS credits and the students can choose how many credit points want to take. The sixth module (the seminar) is compulsory for everyone. The final grade of the course is weighted average of modules. Credit points of the modules are used as a weighted factor. Assessment methods of modules vary including learning diaries and different kind of assignments. More information about assessment methods of each module is given during the course.

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Professor Björn Klöve

Other information: The course is arranged in alternate years (even autumn semesters). The course is organised in a co-operation with faculty of Technology, Economics, Social Sciences, Biology and the Thule institute. The name and ECTS credits of each modules:

Module 1: 3 cr, Introduction to EIA
Module 2: 1 cr, Hydrology and Water Resources
Module 3: 1 cr, Ecology
Module 4: 1 cr, Cost-Benefit Analysis and Valuation of Environmental Benefits
Module 5: 1 cr, Social Impact Assessment
Module 6: 1 cr, Seminar

488405S ENVIRONMENTAL ISSUES IN THE BARENTS REGION

ECTS credits: 5 cr

Language of instruction: English

Timing: In period 6.

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 environmental landscape of the Barents region, the impacts of past activities, and projections of future economic and social development.

Contents: Annually changing theme, e.g. on 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), sustainable energy, socio-economic issues (health, indigenous cultures, languages)

Mode of delivery: Implemented as face-to-face teaching.

Learning activities and teaching methods: Lectures, field-trips and course assignments.

Target group: In University of Oulu: Especially the new students of the Master's Degree Programme (BCBU) in Environmental Engineering (BEE), and also, the students of the Sustainable Energy (SE) orientation of the Study Programmes of Process Engineering and Environmental Engineering; in addition: the students of the BEE/BCBU partner universities.

Prerequisites and co-requisites: For BEE students, admission to the Master's programme, for which minimally a bachelor's degree is required. For other target group students, the Bachelor level studies in process or environmental engineering or respective knowledge. For all, the preceding Master level studies or respective knowledge. Please note that for participation to the course; all students are required to have good English language skills!

Recommended optional programme components: The other courses of the Master's phase curriculum so far.

Study materials: Lecture materials are provided during the course and in Optima.

Assessment methods and criteria: Assessment is based on the performance of the different assignments and on participation to the field trips.

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Eva Pongrácz (Thule Institute, University of Oulu)

Other information: Resources allowing, the course is organized intensively during one week in location outside of Oulu, at the Oulanka Research Station, Kuusamo Finland as part of the BCBU cooperation. Or, the course the course might be organized, e.g., at the University of Oulu, Finland.

488205S ENVIRONMENTAL LOAD OF PROCESS INDUSTRY

ECTS credits: 4 cr

Language of instruction: English

Timing: 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 different types of (chemical, wood, metallurgical…) industry. He/she is able to explain the type, quality, quantity and sources of the 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 can 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.

Learning activities and teaching methods: face-to-face teaching

Mode of delivery: Lectures 30h

Target group: Master's degree students of the Department of Process and Environmental Engineering

Prerequisites and co-requisites: 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.

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

Assessment methods and criteria: Written final exam

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Satu Ojala

Other information: The exact contents of the study course may vary yearly. May contain a short exercise work.

477041S EXPERIMENTAL DESIGN

ECTS credits: 5 cr

Language of instruction: English

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.

Mode of delivery: Lectures and practical work.

Target group: Master's students in DPEE

Study materials: Material given in the lectures.

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

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Professor Kauko Leiviskä

488404A GLOBAL CHANGE

ECTS credits: 5 cr

Language of instruction: English

Timing: In periods 1-2.

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.

Mode of delivery: Implemented as face-to-face teaching.

Learning activities and teaching methods: Lectures, assignments and student's presentations.

Target group: Especially, but not restricted to, the new students of the Master's Degree Programme (BCBU) in Environmental Engineering (BEE) and the students of the Sustainable Energy (SE) orientation of the Study Programmes of Process Engineering and Environmental Engineering.

Prerequisites and co-requisites: For BEE students, admission to the Master's programme, for which minimally a bachelor's degree is required. For other target group students, the Bachelor level studies in process or environmental engineering or respective knowledge. For all, the preceding Master level studies or respective knowledge.

Recommended optional programme components: The other courses of the Master's phase curriculum so far.

Study materials: Lecture materials are provided during the course and in Optima.

Assessment methods and criteria: Assessment is based on the performance of the different assignments.

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Ali Torabi Haghighi (Water and Environmental Engineering Laboratory, University of Oulu)

488108S GROUNDWATER ENGINEERING

ECTS credits: 5 cr

Language of instruction: English

Timing: The course unit is held in the autumn semester, during periods 1-2

Learning outcomes: Upon completion of the course, the student will have knowledge on water retention and flow in soils, basic theories about hydraulics of groundwater systems, groundwater quality, groundwater use and modelling. Students learn to define hydraulic characteristics of soil and aquifers. After the course students are able to estimate key factors influencing on discharge and water quality of groundwater and to use general methods to calculate groundwater flow. They also know how to plan, manage, and protect groundwater resources in a sustainable way.

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

Mode of delivery: Face-to-face teaching

Learning activities and teaching methods Lectures (10 h), calculus exercises (9 h), MODFLOW modelling exercises (16 h), modelling report (40 h), and self-study (60 h).

Target group: Master students in the Water and Engineering / Water and Environment study options of the Environmental Engineering programmes

Prerequisites and co-requisites: The required prerequisite is the completion of the following course prior to enrolling for the course unit: 488102A Hydrological Processes

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

Assessment methods and criteria: Modelling assignment (40 % of the grade) and exam (60 % of the grade).

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Professor Björn Klöve and PhD candidate N.N.

Other information: The course is arranged in alternate years (odd autumn semesters).

488102A HYDROLOGISET PROSESSIT (HYDROLOGICAL PROCESSES)

ECTS credits: 5 cr

Teachers: Björn Klöve, Anna-Kaisa Ronkanen

Language of instruction: Finnish / Self-study course in English

Timing: Implementation in 4th-5th periods.

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.

Mode of delivery: Self-study course in English

Learning activities and teaching methods Lectures, calculus sessions and an assignment.

Target group: Master students in the Water and Engineering / Water and Environment study options of the Environmental Engineering programmes

Recommended optional programme components: Material and Energy Balances recommended

Recommended or required reading: 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: Examination (1-5), the assignment (pass/fail).

Person responsible: Professor Björn Klöve

Other information: English version (self-study package) for the course is available.

488104A INDUSTRIAL AND MUNICIPAL WASTE MANAGEMENT

ECTS credits: 5 cr

Language of instruction: English

Timing: The course unit is held in the spring semester, during periods 5-6

Learning outcomes: The student will acquire a wilder view of what is waste and how it is generated and managed in communities and industries. 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 including their sustainability and related environmental impacts. As well as, how a series of factors influence the planning of waste management activities in industries and municipalities. The student will also be able to understand the energy and material recovery potential within the waste sector.

Contents: Waste management hierarch, waste prevention principle, municipal waste management, waste management in industries, waste legislation, municipal and industrial waste treatment methods, international treaties related to waste management (Basel convention and Clean Development Mechanism projects: carbon trading), waste to energy principle.

Mode of delivery: Face-to-face teaching

Learning activities and teaching methods: Learning methods: A) Active learning method: Lectures (24 h), group work (45 h), self-study for examination (55,5 h) and field visits (8 h) or alternatively B) Group work (45 h), self-study for examination (87,5 h).

Target group: Students in bachelor program of environmental engineering

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

Assessment methods and criteria: *The students' performance during the course is assessed by successful completion of stages A and B as follow: A) Completion of the course work which consists of* group exercises 1 and 2 each carrying 30% weight in the course final grade; B) Course examination carrying 40% weight in the course final grade (Note that a passing grade (1-5) for the course examination is required for the completion of the course).

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Elisangela Heiderscheidt

488203S INDUSTRIAL ECOLOGY

ECTS credits: 5 cr

Language of instruction: English

Timing: 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.

Learning activities and teaching methods: face-to-face teaching

Mode of delivery: Lectures 30h. Compulsory exercise work.

Target group: Master's degree students of the Department of Process and Environmental Engineering

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

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Satu Ojala, Rauli Koskinen, Eva Pongrácz

488113S INTRODUCTION TO SURFACE WATER QUALITY MODELLING

ECTS credits: 5 cr

Language of instruction: English

Timing: The course unit is held in the autumn semester, during periods 2-3

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.

Mode of delivery: Face-to-face teaching

Learning activities and teaching methods: Lectures, exercises and modelling with Matlab.

Target group: Master students in the water engineering orientation of the Environmental Engineering program

Prerequisites and co-requisites: Basic university level knowledge of mathematics and physics is required. The required prerequisite is also the completion of the following course prior to enrolling for the course unit: 488102A Hydrological Processes

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).Lecture hand-outs and other materials delivered in lectures.

Assessment methods and criteria: Totally six assignments must be done and graded on the scale 1-5. The final grade of the course is average grade of them. Also final examination must be completed but it is graded on the scale pass/fail.

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: University lecturer Anna-Kaisa Ronkanen

Other information: The course is arranged in alternate years (even autumn semesters).

488401A INTRODUCTION TO THE ENVIRONMENTAL AND SOCIO-ECONOMICAL ISSUES OF THE BARENTS REGION

ECTS credits: 2 cr

Language of instruction: English

Timing: In period 1-2.

Objective: This course provides introduction to the Barents region from different perspectives.

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 technological factors therein, and evaluate those issues against the respective issues in his or her country of origin.

Contents: The Barents environment; History of the Barents collaboration and the political and economic profile of the Barents Region; Infrastructure and building in the Barents Region; People, cultures and livelihoods in the Barents Region; People and health at the Barents Region, Technological challenges and possibilities in the Barents Region.

Mode of delivery: Implemented as face-to-face teaching.

Learning activities and teaching methods: Lectures, discussions, visits, learning diary, portfolio.

Target group: Especially, but not restricted to, the new students of the Master's Degree Programme (BCBU) in Environmental Engineering (BEE) and the students of the Sustainable Energy (SE) orientation of the Study Programmes of Process Engineering and Environmental Engineering.

Prerequisites and co-requisites: For BEE students, admission to the Master's programme, for which minimally a bachelor's degree is required. For other target group students, the Bachelor level studies in process or environmental engineering or respective knowledge. For all, the preceding Master level studies or respective knowledge.

Recommended optional programme components: The other courses of the Master's phase curriculum so far.

Study materials: Lecture materials are provided during the course and in Optima.

Assessment methods and criteria: Participation to the lectures and writing learning diaries therein, and final portfolio as an exam

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: BEE Study Advisor Marita Puikkonen (Department of Process and Environmental Engineering, University of Oulu)

488118S LABORATORY EXERCISES AND FIELD MEASUREMENTS IN ENVIRONMENTAL ENGINEERING

ECTS credits: 10 cr

Language of instruction: English

Timing: The course unit is held during periods 1-6

Learning outcomes: Upon completion the student should be able to design field measurements and understand the quality of sampling and measurements in the field of environmental engineering. The student also improves skills of working in a team of fellow students to share expertise and execution responsibilities. The student understands the laboratory testing procedures and the associated parameters that help in estimating the water, soil and waste water properties. The student knows how to use different methods for field measurement and sampling in water and geotechnical issues. The student can take considering the safety during the laboratory works and field measurements. After the course, the student can write detailed engineering reports.

Contents: Units of measurements, Error and mistake in laboratory works and field measurements. Laboratory works on Fluid mechanics and open channel hydraulics contain different method for discharge measurement, Bernoulli equation, Momentum equation, gates and wires, hydraulic jump and tracer test. Laboratory works on Geotechnical and Geoenvironmental Engineering contain sieving test, hydrometer test, Atterberg limits test, proctor test, direct shear box test and eudiometer test. Laboratory works on Ground water engineering contain hydraulic conductivity (K), specific yield (S), porosity (n) and PF curve test, Darcy low and groundwater flow, contaminant transport. Laboratory works on water and waste water engineering contain Jar test experiment, settling velocity , limestone ($CaCO_3$) filtration, aeration determination of Fe, Cl, and Mn. Introduction to surveying and preparing a topography map, Global position system (GPS), soil and water sampling, CO_2 measurements from soil. Field measurement experiences in cold climate

Mode of delivery: Face-to-face teaching, laboratory working.

Learning activities and teaching methods: Activating learning method: Lectures (30 h), group work (240 h)

Target group: Only for master students in the water engineering / water and environment study options of the Environmental Engineering program

Prerequisites and co-requisites: The required prerequisite is the completion of the following courses prior to enrolling for the course unit: 488102A Hydrological Processes, 488108S Groundwater Engineering, 488110S Water and Wastewater Treatment, 488115S Geomechanics, 488113S Introduction to Surface Water Quality Modelling

Study materials: Field measurements and Laboratory work instruction, lectures

Assessment methods and criteria: Each exercise is evaluated graded on the scale 1-5. The final grade of the course is weighted average of following parts: participate in the lectures (10%), participate in the laboratory and field works (20% if the respective report will be presented), assignments (8%), and reports (62%).

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: University Teacher Ali Torabi Haghighi

477306S NON-IDEAL REACTORS

ECTS credits: 5 cr

Language of instruction: English

Timing: Implementation in autumn semester during 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 analyse the effect of non-ideal mixing conditions on the behaviour of a reactor. He/she is capable of explaining the mechanisms of heterogeneous reactions, especially with methods that are used to analyse 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.

Mode of delivery: Lectures including exercises.

Learning activities and teaching methods: Lectures 35 h, exercises 12 h, homework 12 h.

Target group: Master's degree students of the Department of Process and Environmental Engineering.

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. Homework assignments affect the course grade.

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Professor Riitta Keiski

488400A ORIENTATION TO THE BEE STUDIES

ECTS credits: 1 cr

Language of instruction: English

Timing: In period 1-4.

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 completion of the course the student is able to understand how to finance a mining project; he/she will be able to describe the requirements of venture capital financing and other type of financing, the sources of mining financing and how to seek financing; the sources of financing and he/she understands the importance of cash flow, NPV and IRR calculations. The student will understand the parameters impacting the value of a mining project. The student will be able to prepare a simple valuation model of exploration properties and companies.

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. Compulsory parts: 1. the 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. 3. Participation to student tutoring during the autumn term. 4. Planning of PSP (personal study plan) and ratification of the study orientation.

Mode of delivery: Implemented as face-to-face teaching.

Learning activities and teaching methods: Lectures, visits, seminars, exercises, etc.

Target group: The new students of the Master's Degree Programme (BCBU) in Environmental Engineering (BEE) only.

Prerequisites and co-requisites: For BEE students, admission to the Master's programme, for which minimally a bachelor's degree is required.

Recommended optional programme components: The other courses of the Master's phase curriculum so far.

Study materials: All materials will be delivered on need-basis (e.g. BEE-study guide book, etc.)

Assessment methods and criteria: Active participation all the different parts of the course; planning the first version of the PSP together with the Study Advisor (compulsory).

Grading: Verbal scale Passed/Failed

Person responsible: BEE Study Advisor Marita Puikkonen (Department of Process and Environmental Engineering, University of Oulu)

721236A PRINCIPLES OF ENVIRONMENTAL ECONOMICS

ECTS Credits: 5 cr

Language of instruction: Finnish / The course can be passed with a literature examination in English. The students wishing to do that should contact the teacher.

Timing: Period C of Oulu Business School (corresponding to periods 4-5 of DPEE)

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.

Learning activities and teaching methods: Independent reading of the textbooks. Information on possible lectures will be given later.

Recommended or required reading: Tietenberg, T: Environmental Economics and Policy, 4th ed., 2004 Check availability from here.

Assessment methods: Literature examination.

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Assistant professor Artti Juutinen, Oulu Business School

477309S PROCESS AND ENVIRONMENTAL CATALYSIS

ECTS credits: 5 cr

Language of instruction: English

Timing: Implementation in autumn semester, during 2nd period.

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

Learning outcomes: The student can define the fundamentals and history of catalysis and explain its economical and environmental meaning. He/she is capable of specifying the design, selection and testing of catalysts and catalytic reactors and processes, and of explaining the most important industrial catalytic processes, 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.

Mode of delivery: Lectures including design exercises.

Learning activities and teaching methods: Lectures 30 h, exercises 10 h and homework 30 h.

Target group: Master's degree students of the Department of Process and Environmental Engineering.

Prerequisites and co-requisites: The courses 477011P Introduction to Process and Environmental Engineering I, 488011P Introduction to Environmental Engineering, 780109P Basic Principles in Chemistry and 477306S Non-ideal reactor 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 and homework.

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: University lecturer Mika Huuhtanen

477203A PROCESS DESIGN

ECTS credits: 5 cr

Language of instruction: English

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.

Mode of delivery: Lectures and design group exercises.

Target group: Bachelor students in DPEE

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.

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Responsible person: University Teacher Jani Kangas

488202S PRODUCTION AND USE OF ENERGY

ECTS credits: 3 cr

Language of instruction: English

Timing: 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 related to different 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 can explain the environmental impacts of energy production and is able to compare the environmental impacts of different ways of producing energy. He/she can 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 transmission networks, storing and distribution of electricity. Distribution and adequacy of energy resources. Effects of environmental agreements on the use of the energy resources. Comparison of different energy production methods and fuels by their environmental impacts. Energy markets. Development views of the energy technologies.

Learning activities and teaching methods: face-to-face teaching

Mode of delivery: Lectures 30h

Target group: Master's degree students of the Department of Process and Environmental Engineering

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

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Mika Huuhtanen

477321S RESEARCH ETHICS

ECTS credits: 3 cr

Language of instruction: English

Timing: Implementation in spring semester during 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 recognize 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.

Mode of delivery: Lectures and team work.

Learning activities and teaching methods: Lectures 25 h, practical work 15 h.

Target group: Master's degree students of the Department of Process and Environmental Engineering.

Recommended optional programme components: This course is proposed to be taken within the Research module.

Study materials: In English: 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.

Assessment methods and criteria: Practical work assignments affect the course grade. Examination and a learning diary.

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Professor Riitta Keiski

477307S RESEARCH METHODOLOGY

ECTS credits: 2 or 5 cr

Language of instruction: English

Timing: Implementation in autumn and spring semesters during 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.

Mode of delivery: Miniproject based on lectures in Optima during autumn term, contact lectures, laboratory training period during spring term.

Learning activities and teaching methods: Contact lectures 6 h, miniproject 15 h, training period 70 h.

Target group: Master's degree students of the Department of Process and Environmental Engineering.

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.

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: University lecturer Mika Huuhtanen

Other information: 2 cr gained when only Optima period (in autumn semester) is finalized. Full 5 cr include both Optima and training periods.

555321S RISK MANAGEMENT

ECTS credits: 3 cr

Language of instruction: English

Timing: Periods 1-3

Objective: 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 can explain the key concepts of risk and risk management. The student can describe risk classifications and can explain the importance of the risk management to organizations. The student can analyze 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 organizational 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.

Learning activities and teaching methods: 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, or 0-471-12104-5; Lecture materials.

Assessment methods: Exam and/or group work.

Person responsible: Professor Pekka Kess, Dept of Industrial Engineering and Management

477503S SIMULOINTI (SIMULATION)

ECTS Credits: ***3 cr***

Language of instruction: Finnish and English

Timing: Implementation in 3rd period

Objective: The objective of the course is 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 (S), dynamic S. Intelligent methods in S, S in automation, event handling in continuous S, S of production processes, distributed S, integration with other systems, S languages and programming tools.

Learning activities and teaching methods: 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 also in English.

Recommended or required reading: Lecture notes and exercise materials. Material is in Finnish and in English

Person responsible: University teacher Esko Juuso

488122S STATISTICAL METHODS IN HYDROLOGY

ECTS credits: 5 cr

Language of instruction: English

Timing: The course unit is held in the autumn semester, during periods 1-2

Learning outcomes: Students will be able to explain and apply the general statistical methods used in hydrology. Students can understand for describing a relationship between two hydrologic variables what type of statistical analyses are mostly used. In addition, students can show their findings from the statistical methods analysing in different plot types which are conventional in hydrology and water resources management. Considering some scientific guidelines for writing the reports of assignments, students can be familiar with scientific writing much more than the past.

Contents: Statistical analyses of a hydrologic variable: 1) Summary statistics like mean, maximum, minimum, median, standard deviation and etc. 2) Probability distributions such as histograms, box, quantile and plots of normal, gamma, log-normal and generalized extreme value distributions. 3) Analyzing and plotting of significant correlations between a hydrologic variable and a meteorological variable. 4) Using regression line model with 95% confidence and prediction intervals, and also check residuals of the model. 5) Trend and time series analysis, and plotting time versus data in anomaly and scatter plots.

Mode of delivery: Face-to-face teaching

Learning activities and teaching methods: In total, 135 hours of learning activities consisting of lectures (9 h), instructed computer sessions (18 h), and return assignments (108 h)

Target group: Master students in the water engineering orientation of the Environmental Engineering program

Prerequisites and co-requisites: The required prerequisite is the completion of the following course prior to enrolling for the course unit: 488102A Hydrological Processes, and 477033A Programming in Matlab or corresponding Matlab skills.

Study materials: Helsel, DR, & Hirsch, RM, 2002. Statistical Methods in Water Resources (available online). Loucks, DP, van Beek, E, Stedinger, JR, Dijkman JPM., Villars, MT, 2005. Water Resources Systems Planning and Management (available online).

Assessment methods and criteria, grading: Variable assessment methods where each submission is graded and weighted separately: A) report of group work on assignments (3 returned assignments in total 75%), and B) final exam (25%). Final grade of the course is average of assignments and final exam. In the numerical scale zero stands for a fail.

Person responsible: Professor Björn Klöve

Other information: The course is arranged in alternate years (odd autumn semesters).

488402A SUSTAINABLE DEVELOPMENT

ECTS credits: 3 cr

Language of instruction: English

Timing: In period 3.

Objective: This course aims to provide the students a 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: Different multidisciplinary aspects in sustainable development, 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.

Mode of delivery: Implemented as face-to-face teaching.

Learning activities and teaching methods: Multidisciplinary, intensive and interactive course with case studies. Seminar presentations and court case exercises or negotiation simulations.

Target group: Especially, but not restricted to, the new students of the Master's Degree Programme (BCBU) in Environmental Engineering (BEE) and the students of the Sustainable Energy (SE) orientation of the Study Programmes of Process Engineering and Environmental Engineering.

Prerequisites and co-requisites: For BEE students, admission to the Master's programme, for which minimally a bachelor's degree is required. For other target group students, the Bachelor level studies in process or environmental engineering or respective knowledge. For all, the preceding Master level studies or respective knowledge.

Recommended optional programme components: The other courses of the Master's phase curriculum so far.

Study materials: Lecture materials are provided during the course and in Optima.

Assessment methods and criteria: Course evaluation will be based on activity during the seminar and other course assignments.

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Hanna Valkama (Mass and Heat Transfer Process Laboratory, University of Oulu), or N.N.

477305S VIRTAUSDYNAMIIKKA (FLOW DYNAMICS)

ECTS Credits: 5 cr

Language of instruction: Finnish – ask the teacher about the possibility to take this course in English.

Timing: Implementation in 2nd period.

Objective: To familiarize the student with mathematical modelling 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.

Learning activities and teaching methods: Lectures and compulsory exercise done in small groups.

Recommended optional programme components: Courses 477301A Momentum Transfer, 031019P Matrix Algebra and 031022P Numerical Methods are recommended beforehand (or respective knowledge).

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

Assessment methods: Examination and exercise.

Person responsible: Laboratory manager Esa Muurinen

488110S WATER AND WASTEWATER TREATMENT

ECTS credits: 5 cr

Language of instruction: English

Timing: The course unit is held in the autumn semester, during periods 1-2

Learning outcomes: Upon completion of the course, the student will be able to explain basic processes of water and wastewater treatment and can do the selection of needed process units and can dimensioning those.

Contents: Characters of raw water, tap water and wastewater; used process units in water and waste water treatment; selection of process units; dimensioning treatment units and unit processes.

Mode of delivery: Face-to-face teaching

Learning activities and teaching methods: lectures (50 h), exercises (40 h), self-study (45 h)

Target group: Students in master program of environmental engineering

Prerequisites and co-requisites: The required prerequisite is the completion of the following course or to have corresponding knowledge prior to enrolling for the course unit: 488011P Introduction to Environmental Engineering

Study materials: Lecture hand-outs & Kemira, About water treatment. Optional: RIL 124-2, Vesihuolto II; Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse; AWWA, Water quality & treatment; AWWA, Water treatment plant design.

Assessment methods and criteria, grading: Course can be completed A) by book examination (Kemira), the lecture examination and to do 2 exercises OR B) by the final examination and to do 2 exercises. The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: Laboratory Engineer Jarmo Sallanko

488117S WATER RESOURCES MANAGEMENT

ECTS credits: 5 cr

Language of instruction: English

Timing: The course unit is held in the autumn semester, during periods 3-4

Learning outcomes: This course introduces design concepts and principles that must be taken into account in planning of sustainable use of water resources. After the course students understand different processes, principles and mathematical methods used to manage water resources issues.

Contents: Different water uses and interests, hydropower and dam engineering, irrigation and drainage, flood control and management, river restoration cases, sediment transport problems, peatland land use, acid sulphate soils, optimization and simulation, lake restoration, socio-ecological aspects in water resources.

Mode of delivery: Face-to-face teaching, assignments

Learning activities and teaching methods: Variable learning methods: lectures and assignments

Target group: Master students in the water engineering orientation of Environmental Engineering program

Prerequisites and co-requisites: The required prerequisite is the completion of the following course prior to enrolling for the course unit: 488102A Hydrological Processes

Study materials: Water Resources Systems Planning and Management: An Introduction to Methods, Models and Applications. (Loucks and van Beek, 2005, ISBN 92-3-103998-9)

Assessment methods and criteria: Variable assessment methods where each submission is graded and weighted separately: Assignment 1 (30%), Assignment 2 (20%) and Assignment 3 (50%). More detailed instructions will be given in the course.

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: D.Sc.(Tech.) Hannu Marttila and University Teacher Ali Torabi Haghighi

Other information: The course is arranged in alternate years (odd autumn semesters).

488012A YMPÄRISTÖLAINSÄÄDÄNTÖ (ENVIRONMENTAL LEGISLATION)

ECTS credits: 5 cr

Language of instruction: Only Finnish on 2012-

Timing: The course unit is held in the spring semester, during periods 4-5

Learning outcomes: Upon completion of the course, the student will be able to explain the main component of Finnish environmental legislation and knows the structure of environmental administration in governmental and municipal level; authorities, jurisdiction and duties. The student will be able to understand differences between EIA and environmental permits. Having completed the course, the student knows what permits and acts must be considered in different cases relating to mining, water and energy initiatives.

Contents: Legislation of environmental protection and use of natural resources in Finland and Europe, environmental administration, 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, basics of international environmental legislation and co-operation among European Union in the field of environmental legislation.

Mode of delivery: Face-to-face teaching

Learning activities and teaching methods: Variable learning methods: A) Activating learning method: Lectures (22 h), group work (45 h), self-study (61 h) and seminar (4 h) or alternatively B) examination: Lectures (22 h), self-study (110 h).

Target group: Students in bachelor program of environmental engineering

Prerequisites and co-requisites: No

Study materials: Ympäristöoikeuden pääpiirteet (Ekroos, Kumpula 2010, ISBN: 9789510361283), lectures and lecture material

Assessment methods and criteria: Variable assessment methods where each submission is graded and weighted separately: A) report of the group work and seminar presentation (50%), opponent work (30%) and learning diaries (20%). B) Examination (80%) and learning diaries (20%). The instructions for the different assessment methods and criteria will be given in the course.

Grading: The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible: University lecturer Anna-Kaisa Ronkanen

6 INTRODUCTION TO THE BARENTS CROSS BORDER UNIVERSITY CO-OPERATION

The Barents Cross Border University, BCBU, is a project aiming to advance the development and joint organisation of international, multidisciplinary master's degree programmes. The project started from the cooperation between universities in Northern Finland and Northwest Russia that has since expanded and today there are partners from the whole Barents Region and even wider: This Finnish-Russian project has been strengthened with co-operation with Swedish and/or Norwegian universities, and some of the BCBU programmes have established co-operation even over the Arctic Circle, with, e.g., University of Manitoba in Canada. The cooperation had a starting point in mutual interests of the partner universities as well as in principles and aims of the partnership programs and the EU's Northern Dimension policy [(18)].

The built-up of the Barents Cross Border University concept started in autumn 2005 and a memorandum of understanding was undersigned on January 2006, followed by the signing of the agreement for the BCBU network cooperation in March 2007. In March 2012, a continuum agreement for the BCBU cooperation was undersigned in Rovaniemi, Finland, by the Finnish and Russian partners. The Master's Degree programmes within BCBU should follow the principles of the Bologna process and the language of teaching should be English. Later the co-operation will also cover doctoral education and research cooperation in the same fields.

Within BCBU, there are currently two partner universities from Finland, and seven from Russia. In addition there are five partners from other countries with bilateral and/or programme-based agreements with the above mentioned Finnish and/or Russian universities. The partners collaborate in different combinations or roles (full/associate partnership) in the five BCBU Master's Degree Programmes.

The BCBU partners from Finland are University of Oulu and University of Lapland in Rovaniemi. From Russia, the partners are Northern (Arctic) Federal University named after M. V. Lomonosov and Northern State Medical University in Arkhangelsk; Petrozavodsk State University and the Karelian State Pedagogical Academy in Petrozavodsk; Murmansk State Technical University, Murmansk State Humanities University, and International Institute of Business Education in Murmansk. The other BCBU 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 to provide currently five two-year (120 ECTS) cooperative Master's Degree programmes, in the fields of social work, environmental engineering, information and communication technology, circumpolar health and well-being, and law. The programmes for environmental engineering (BEE), information systems (GS3D), and circumpolar health and wellbeing (MCH) are coordinated by the University of Oulu, and comparative social work (CSW) and international and comparative law (MICLaw, 90 ECTS) by the University of Lapland.

The combination of the partner universities in each programme is based on the former co-operation and current expertise of the 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:

[18] EU Northern Dimension Policy, see e.g.: http://eeas.europa.eu/north_dim/index_en.htm

Environmental Engineering (BEE) [19]	http://bee.oulu.fi (the web address will change)
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
Intl. & Comparative Law (MICLaw)	http://www.ulapland.fi/?deptid=22930

6.1 General information on the main BCBU/BEE partner universities

Currently six universities collaborate actively within the BEE programme, either inside or outside the BCBU project. These are the next: University of Oulu from Finland; Northern (Arctic) Federal University, Murmansk State Technical University and Petrozavodsk State University from Russia; and Narvik University College from Norway and Luleå University of Technology from Sweden. In the next paragraphs, information is given of these BEE partners and co-operators.

6.1.1 University of Oulu

Please note: The mentioned webpages *[all visited on June 27th, 2012]* are also the source of the below-mentioned information.

For 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. For the Thule Institute and NorTech Oulu, see http://thule.oulu.fi/englanti/index.html.

University of Oulu, Finland, is a full partner in BCBU/BEE

University of Oulu (UO) is an international research and innovation university engaged in multidisciplinary basic research and academic education. It is one of the largest universities in Finland with an exceptionally wide academic base. Internationally pioneering research is conducted as a collaboration of different disciplines. The University encompasses eight fields of study: dentistry, economics, education, engineering, health sciences, the humanities, medicine, and natural sciences. In all, more than 70 different specialist disciplines are represented.

The fields of information technology; biosciences and health; cultural identity and interaction; and environment, natural resources and materials have been defined as special research focus areas. UO cooperates closely with industry and commerce, and has broad connections with hundreds of international research and educational institutions.

The strengths of University of Oulu are its broad academic base, top-level research in its chosen focus areas, and quality education. The University promotes advanced research, education and culture, and strengthens the knowledge and skills base leading to enhanced wellbeing. Its activities ensure the availability of a highly-trained specialist workforce and research capacity.

The university provides a high-quality learning environment for both specialists and generalists in its different study programmes. UO offers currently 18 international Master's Degree programmes (see http://www.degree.oulu.fi) in addition to the tens of national study programmes. Further, several new international master's degree programmes are planned.

The Master's Degree Programme of 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 impact especially the northern areas. The ultimate aim is to find new, sustainable ways of protecting and using the northern environment

[19] University of Oulu BEE is officially called 'Master's Degree Programme (BCBU) in Environmental Engineering', see http://www.finlex.fi/fi/laki/alkup/2009/20091665

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 Global Change in the North Research Programme [(20)] and in the Northern Research Platform of the European Research Area.

In UO, the 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. The specific strong area of the department is its teaching which is based on unit process thinking. 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. Being an expert in the area of engineering education has helped DPEE also in the implementation of the BEE MDP: during the Internal Evaluation of the UO MDPs on 2011, BEE was evaluated to be among the two best Master's Degree Programmes.

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 and especially its unit NorTech Oulu are, in addition to DPEE, the other major contributors to the BEE programme at UO. 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 and NorTech in Oulu, and Oulanka research station in Kuusamo, Finland.

The basis of the 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.

6.1.2 Northern (Arctic) Federal University

Please note: The next webpages *[visited on June 27th, 2012]* are also the source of the below-mentioned information.

Northern (Arctic) Federal University's main webpage, see http://narfu.ru/en/ and for their BCBI/BEE related study programme, see http://narfu.ru/en/international/jep/environment/

NArFU is a full partner in BCBU/BEE.

Northern (Arctic) Federal University (NArFU) in Archangelsk, Russia, is an ambitious university of distinctiveness and innovations designed to meet the needs of the Russian North and the Arctic. Being an educational institution, the university gives particular emphasis on training competitive top quality specialists flourishing in the chosen fields of activities. NArFU offers wide-ranging and high quality programmes of higher, postgraduate and vocational education intended to prepare students for success. Further, they participate actively in organization of joint international educational programmes which enable students to go into higher education in accordance with the requirements of the Bologna process. Being a promising research platform, NArFU also stands a good chance to become a recognized manufacturer of life-changing technologies and innovations in the Arctic region through expanding the range of research activities and strengthening research performance in the region.

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

Over the recent years NArFU together with various European institutions have established collaborative degree initiatives at the undergraduate and graduate levels, in order to promote educational cooperation between partner institutions. Under these jointly developed international degree programs, NArFU accepts a determinate number of international students each year in the areas of Social Sciences, Mathematical and IT sciences, Humanities and others. Students from partner institutions who participate in these joint international programs have to complete most of the studies at their home university and then complete an exchange part (approximately one semester) at one of the partner universities.

NArFU joint international programs have been developed under the auspices of UArctic, Barents Cross Border University (BCBU) collaborative platforms as well as by creating bilateral and multilateral agreements with universities in Northern Finland, Sweden and Norway. Much more international programs are going to be set up as a ripple effect of university's internationalization and transition towards Bologna framework. The international programs with joint or integrated participation of NArFU are the next: the BCBU programmes of Circumpolar Health and Well-being, Comparative Social Work, Software Systems and Services Development, and Environmental Engineering; and in addition, Russian Studies, Bachelor of Circumpolar Studies, and Travel and Tourism Management.

6.1.3 Murmansk State Technical University

Please note: The next webpages *[visited on June 27th, 2012]* are also the source of the below-mentioned information.

Murmansk State Technical University's main webpage, see http://eng.mstu.edu.ru

Murmansk State Technical University is a full member in BCBU/BEE

Murmansk State Technical University (MSTU), Russia, is one of the oldest higher education institutions on the Kola Peninsula. Its history began in 1950, and in the year 2010 the University celebrated the 60-th anniversary. MSTU was founded as Murmansk Higher Marine School which had to provide the rapidly growing fishing fleet with the top-level staff. Their name has been changed several times and was finally transformed into Murmansk State Technical University.

MSTU is nowadays one of the biggest and most important educational centres in the High North of Russia. MSTU has 12 faculties and 38 departments educating students in 28 areas. The main goal is to provide all industry sectors with highly-skilled employees valued both for their deep knowledge, and for their ability to study, communicate and face challenges.

Apart from the teaching activities, MSTU carries out very intensive research and unites students, PhD students, lecturers and researchers. This work is determined by the region's geographical position and its mineral resources. The university is conducting scientific research in oil and gas sphere, heat power engineering, microbiology and biochemistry. In addition, MSTU is supervised by the Federal Fisheries Agency, which makes combining university research and fishing industry one of the key tasks.

International cooperation is also considered to be a very important area, and MSTU has established close contacts with educational institutions and international funds from Scandinavia, Great Britain, France, Holland, Iceland, Poland and Ukraine.

6.1.4 Petrozavodsk State University

Please note: The next webpages *[visited on June 27th, 2012]* are also the source of the below-mentioned information.

Petrozavodsk State University main page, see http://www.petrsu.ru/Structure/structure_e.html

Petrozavodsk State University is an associate member in BCBU/BEE

Petrozavodsk State University (PetrSU), Russia, was founded in 1940 as the Karelian-Finnish University and was renamed in 1956. During its 70-year-long history, the university has trained more than 60000 highly qualified specialists. Among its graduates there are academicians, ministers and world-famous specialists in culture and science, heads of enterprises and workers of various branches of industry of the Northwest and Northern economical regions of Russia.

PetrSU now comprises of 85 chairs and 17 faculties: the Faculties of 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, as well as Preparatory Faculty, and the Faculties of Improvement of Professional Skills, and Postgraduate Education in the Sphere of Medicine. The university also includes 3 branches, of which two are located in Karelia - Priladozhsky branch (Sortavala), Belomorsk branch (Belomorsk) and Kola branch in Apatity, Murmansk region; and further, more than 40 international, regional and university innovation centres, training and production facilities, a publishing house, scientific library (one of the largest libraries in the European North of Russia which funds total more than one million four hundred thousand books), and a botanic garden and several structural subdivisions.

Nowadays teaching staff of PetrSU is more than 1000 people and more than 18 500 under-graduate and graduate students study there.

PetrSU has a high status of large research centre in the field of programming, information technologies, plasma research, microelectronics, mathematics, physics, medicine, biology, history, philology, political and social sciences, law, economy, problems of timber, building and agro-industrial complexes, etc.

PetrSU is a recognized leader among the institutes of higher education of the Northwest Federal District of the Russian Federation in the sphere of international cooperation development. The university 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. Annually PetrSU implements about 30 international projects carried out with the financial support of various international funds, programs and organizations. Bilateral agreements with foreign partner universities on student exchange have been supported for more than 15 years. The most active are exchange programs with the Finnish universities of Helsinki, Oulu, Joensuu, Tampere, Kuopio, and Lappeenranta.

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 Barents Cross-Border University joint project with several universities of Russia and Finland was launched for cooperation in the field of teaching joint master's programmes.

6.1.5 Narvik University College

Please note: The next webpages *[visited on June 27th, 2012]* are also the source of the below-mentioned information.

Narvik University College's main webpage, see http://www.hin.no/?lang=eng

Narvik University College, Norway, has been participating in the education of the UO/DPEE programme within the area of Sustainable Energy.

Narvik University College (NUC) is one of State University Colleges in Norway which offer higher education through various bachelor- and master-level study programmes. NUC was founded in 1994 when the three local institutions (on engineering, economics and nursing) for higher education were joined together.

NUC has a modern and compact campus, a good learning environment and not to mention, easy access to teaching staff. The opportunity of entering a solid research environment is also a great advantage. NUC has good relations with its collaborators within both local and national business communities. It has students from about 20 different countries. A good 10 percent of students have an international background. A large number have come from educational establishments in China and Russia, countries with whom NUC has good partnerships.

The strategic plan of NUC emphasizes that research and development are a necessary and important part of the business, and that education should be research-based and inter-disciplinary. 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 co-operation, NUC is actively developing contacts with educational institutions in other countries and continents.

6.1.6 Luleå University of Technology

Please note: The next webpages *[visited on June 27th, 2012]* are also the source of the below-mentioned information.

Luleå University of Technology's main webpage, see http://www.ltu.se/?l=en

The Luleå University of Technology (LTU), Sweden, has been planned to later collaborate in the sustainable energy programme/study option with OU/DPE/BEE and NUC.

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 is for the most part applied research and is conducted in close collaboration with international and national companies. The research has a turnover of over EUR 80 million and covers 70 research subjects. Today the University has 1600 employees and 17 000 students.