University of Southern Denmark

## Chapter 9

## The programme specific part of the curriculum for:

# MASTER OF SCIENCE IN ENGINEERING (ENVIRONMENTAL ENGINEERING)

**CIVILINGENIØR, CAND. POLYT. I MILJØTEKNOLOGI**

## Curriculum 2014, Version 1.1

Applicable to students admitted September 2014 onwards

*Please note that this version is a translation from Danish. In the event of discrepancies or ambiguity between this translation and the Danish version, the Danish version shall prevail.*

The curriculum is divided into general provisions (Chapters 1-8), a programme specific part (Chapter 9) and the module descriptions of the programme's individual course modules. Students should familiarise themselves with all three parts in order to get a complete overview of the provisions regulating the programme.

*Approved by the Academic Study Board of the Faculty of Engineering on 12 November 2014*

## §1 Job Profiles

Virtually every sector of society is concerned with the environment and sustainability. This provides the environmental engineer with a variety of job opportunities:

- **At companies**: e.g. at the environmental department, the development department or production. The environmental engineer participates in the development of new environmentally friendly technologies in products and in manufacturing processes as well as in solving the company's ongoing environmental tasks in waste water, groundwater, and soil and air pollution. Here the environmental engineer is usually responsible for the development, selection, dimensioning, establishment and management of environmental technology facilities. Moreover, many environmental engineers work closely with the management in strategy and communication, especially at companies with large market shares.
- **At the manufacturer of environmental technologies/CleanTech**: development, design, dimensioning, marketing and sale of products and facilities with environmental aim and content. It could, for example, be suppliers of purification installations for waste water, air, soil, groundwater or waste facilities (collecting, sorting, combustion, recycling, composting, etc.), but it could also be other products and facilities for which the environmental aspect is important such as, for example, sustainable energy facilities (wind turbines, biogas plants, solar collectors, solar cells, etc.).
- **In municipal, regional or governmental administration** (e.g. Danish Environmental Protection Agency, Danish Energy Agency and other government agencies): environmental governance, including environmental approval of companies, waste management, strategic action plans, and environmental services, etc.
- **At the environmental plant**: Dimensioning, design, management and maintenance of waste water plants and waste management plants.
- **At the consultancy**: Consultancy work and project management related to all areas of environmental management, i.e. the same tasks as above only as a consultant.
- **At the university/knowledge institution**: research, development and innovation in relation to the chain of cause and effect, theory, methods, models, tools for analysis and assessment of environmental aspects and to create environmentally friendly technologies and solutions.
- **With NGO's, trade associations, interest groups and other major social players**: e.g. The Danish Society for Nature Conservation, The Danish Competition and Consumer Authority, trade associations for the industry, agriculture, fishery, etc., and similar social players. Here the environmental engineer will work in project management, environmental assessment, environmental strategies, environmental law, communication, etc., within subjects of current interest.

## §2 Competence Profile

The learning outcomes of the programme are based on laws and regulations in the subject area. In addition, they are based on the job functions that graduate engineers are expected to master and on the requirements to post-graduate personal and academic development.

*There are several non-environmental competence requirements for graduated engineers, which are described in the general provisions of the curriculum.*

Especially for graduates in Environmental Engineering it is expected that they:

A. have acquired specific knowledge within the academic profiles of the programme based on high level international research

B. are able to disseminate and discuss scientific knowledge and results to people with different academic and professional qualifications

C. are able to understand and describe scientific problems based on own or other's research based knowledge, including develop working hypothesis for scientific work

D. can apply the methods and tools associated with the specific subject areas of the programme's academic profiles related to the job profile described in §1

E. are able to initiate and contribute to academic and interdisciplinary collaborations, including assuming responsibility for own work

F. are able to plan and carry out own academic and personal development

Based on this knowledge the graduate engineer must be able to solve complex technical problems, and design and implement complex technological products and systems in a social context. For environmental engineers this means that they:

G. are able to design environmentally optimised and efficient solutions that match the social infrastructure. A holistic approach is the backbone of our teaching enabling the student to manage and assess environmental consequences of engineering solutions and decisions

H. can analyse and optimise products, processes and productions based on considerations related to especially resources and the environment. Including understand and apply tools such as Life Cycle Assessment, Energy Systems Analysis, Material Flow Analysis, Process Integration, among others

I. can contribute to and partake in the research areas of sustainable waste management (technologies and systems), carbon management and bio-systems, design of sustainable energy systems, water management and industrial and household technologies as well as design and innovation of industrial products and processes, etc.

J. are able to undertake planning, consultancy and specialist tasks in the following key competences of the programme: System analysis (life cycle assessment), energy system optimisation, Cleantech (cleaner technology) related to products and productions, as well as waste management and optimisation of resource utilisation in a social perspective.

The above mentioned learning outcomes are based on the general engineering skills as described in DSMI as well as on academic competences in a variety of technical, scientific and socio-related disciplines and shown in the subject columns of the programme.

**Qualifications Matrix**

| AN ENVIRONMENTAL ENGINEER WILL HAVE ACQUIRED … | EM-LCA (1. sem) | EM-BEM (1. sem) | EM-CTPI (1. sem) | EM-GLSU (1. sem) | EM-DFE (2. sem) | EM-WAM (2. sem) | EM-IWT (2. sem) | EM-VIM (3. sem) | Thesis (4. sem) |
|---|---|---|---|---|---|---|---|---|---|
| RESEARCH BASED KNOWLEDGE OF | | | | | | | | | |
| In the academic profiles of the programme to have acquired specific knowledge based on high level international research | x | | x | | x | x | x | | |
| SKILLS TO, ON A SCIENTIFIC LEVEL, | | | | | | | | | |
| disseminate and discuss scientific knowledge and results to people with different academic and professional qualifications | x | x | x | x | x | x | x | x | |
| understand and describe scientific problems based on own or other's research based knowledge, including develop working hypothesis for scientific work | x | | | x | | x | | | |
| apply the methods and tools associated with the specific subject areas of the study programme's academic profiles related to the job profile of the programme | x | x | | | | X | x | x | x |
| initiate and contribute to academic and interdisciplinary collaborations, including assuming responsibility for own work | | | | | | | | X | X |
| plan and carry out own academic and personal development | | | | X | | x | x | | x |

*Approved by the Academic Study Board of the Faculty of Engineering on 12 November 2014*

| COMPETENCES TO ACADEMICALLY AND INTERDISCIPLINARILY | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| design environmentally optimised and efficient solutions that match the social infrastructure. A holistic approach is the back-bone of our teaching enabling the student to manage and assess environmental consequences of engineering solutions and deci-sions | x | | | x | x | | x | | |
| analyse and optimise products, processes and productions based on considerations related to especially resources and the envi-ronment. Including understand and apply tools such as Life Cycle Assessment, Energy Systems Analysis, Material Flow Analysis, Pro-cess Integration, among others | x | | x | | x | | | | |
| contribute to and partake in the research areas of sustainable waste management (technologies and systems), carbon manage-ment and bio-systems, design of sustainable energy systems, wa-ter management and industrial and household technologies as well as design and innovation of industrial products and processes, etc. | | | | | | x | | | |
| undertake planning, consultancy and specialist tasks in the key competences of the programme: System analysis (life cycle as-sessment), energy system optimisation, Cleantech (cleaner tech-nology) related to products and productions, as well as waste management and optimisation of resource utilisation in a social perspective. | x | x | | x | | x | | x | x |

## §3 Subject Columns

The academic competences of environmental engineers primarily fall within the below subject columns of the master programme.

- Assessment of environmental impact
- System modelling, system analysis and life cycle assessment
- Process integration and cleaner technology
- Characterisation methods and processing techniques for waste, water, etc.
- Material flow analysis

In addition students are expected to have general subject knowledge of the below, acquired with the qualifying bachelor degree:

- Chemistry: General, organic and inorganic chemistry, chemical analysis, materials and material chemistry
- Mathematics and physics: Mathematics, statistics, physics and modelling/simulation
- Experimental methods
- Personal and learning competences

# §4 Structure and Modules

## 4.1 Environmental Engineering (autumn start)

<table>
<tr><td>Semester</td><td colspan="30">Modules</td></tr>
<tr><td>4</td><td colspan="30">Thesis</td></tr>
<tr><td>3</td><td colspan="5">Methods in Science</td><td colspan="5">PDCDFE<br>Product and Supply Chain Design for Environment</td><td colspan="5">Elective</td><td colspan="5">Elective</td><td colspan="10">Electives/Thesis/In-company Period*</td></tr>
<tr><td>2</td><td colspan="10">EM-WAM1<br>Waste Management<br>LCA Project on Waste System or End of Life</td><td colspan="10">Industrial Water Technology</td><td colspan="5">Elective</td><td colspan="5">Elective</td></tr>
<tr><td>1</td><td colspan="15">EM-LCA1<br>System Analysis and Energy System Analysis<br>Project on Product Case or Energy System</td><td colspan="5">EM-BEM<br>Business and Economics</td><td colspan="5">EM-CTPI<br>Cleaner Technology and Process Integration</td><td colspan="5">EM-GLSU<br>Global Sustainability</td></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td></tr>
</table>

* If the master's thesis is experimental, the student may choose to spend 10 ECTS elective courses on the 3rd semester on the thesis work. The master's thesis will then be extended to 40 ECTS. The student may also choose to spend 15 ECTS elective courses on an In-company Period (F-VT).

| Explanation with a 30 ECTS thesis | Total ECTS |
|---|---|
| **Compulsory courses** | 60 |
| **Electives** | 30 |

## 4.2 Environmental Engineering (spring start)

<table>
<tr><th>Semester</th><th colspan="30">Modules</th></tr>
<tr><td>4</td><td colspan="30">Thesis</td></tr>
<tr><td>3</td><td colspan="5">Methods in Science</td><td colspan="5">Elective</td><td colspan="5">Elective</td><td colspan="5">Elective</td><td colspan="10">Electives/Thesis/In-company Period*</td></tr>
<tr><td>2</td><td colspan="10">Energy System Analysis<br>Project on Energy System</td><td colspan="5">EM-BEM<br>Business and Economics</td><td colspan="5">EM-CTPI<br>Cleaner Technology and Process Integration</td><td colspan="5">EM-GLSU<br>Global Sustainability</td><td colspan="5">PDCDF<br>Product and Supply Chain Design for Environment</td></tr>
<tr><td>1</td><td colspan="15">EM-LWA<br>Consequential Life Cycle Assessment and Waste Management</td><td colspan="10">EM-IWT<br>Industrial Water Technology</td><td colspan="5">Elective</td></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td></tr>
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* If the master's thesis is experimental, the student may choose to spend 10 ECTS elective courses on the 3rd semester on the thesis work. The master's thesis will then be extended to 40 ECTS. The student may also choose to spend 15 ECTS elective courses on an In-company Period (F-VT).

| Explanation with a 30 ECTS thesis | Total ECTS |
|---|---|
| **Compulsory courses** | 60 |
| **Electives** | 30 |

## §5 Academic Objectives and Ambitions

**OBJECTIVES**

The objective of the common, constituent subject knowledge is multiple.

First, it provides students with a profound understanding of the mechanisms of global environmental challenges related to industrial development and the possibility to push this development in a more sustainable direction. Resource utilisation is used as a theme to analyse the interaction between production, consumption and disposal/recycling of resources.

Second, it provides students with the necessary tools for analysing the environmental impacts of an anthropogenic system and identifying the possibilities for reducing these, while taking into account the financial conditions.

Finally, students must learn to apply the above mentioned approaches in a scientific context.

The common, constituent subjects and the elective courses ensure that the environmental engineer, based on the scientific foundation and practice of the profession, can:

- apply and (further)develop advanced methods of system analysis for the analysis of industrial systems, biotic and abiotic resources, and biosystems
- actively participate in research to develop new products and technologies within separation and processing of waste, energy conversion, efficient cleaning methods, and cleaner technology
- advice authorities and companies on the production of bioenergy and other technologies for environmental improvement.

The academic profile ensures that the environmental engineer graduated from SDU is able to solve complicated problems in environmental engineering disciplines through ’eco-innovation’ and contribute to implement these solutions.

The objective of the academic profile is a high international and professional research based knowledge in process integration, integrated water treatment and resource recycling and that graduates can apply and further-develop the scientific methods in these areas.

Together with the competences acquired at bachelor level the academic profile ensures that the environmental engineer, based on the scientific foundation and practice of the profession, can:

- analyse a production, a product or a system from an environmental point of view, including identifying the potentials for optimisation of resource usage or minimise the environmental impact
- identify and develop technological improvements of a production through altered or optimised processes or technologies, internal recycling systems, or modified products
- design and develop technological improvements of a product through changed or optimised functionality, changed or optimised choice of material, reduced energy consumption, or design for ’End-of-life’ / recycling
- identify optimisation potential through optimised interaction between the technological players in a supply chain, a production network, or a geographically defined area

**Academic themes:**

All environmental engineers must learn about:

- **global challenges of today** – including the impact of manmade technology and nature exploitation
- **basic methodology in life cycle assessment / system analysis** – as a tool to analyse the effect and identify the possibilities for reducing them. This tool is tested further on specific product cases
- **general scientific theory and methods**

Moreover, it is compulsory to learn about the following solution approaches and social structures:

- **innovation as a means to increase sustainability / design of products with reduced environmental impact** – including the definition and scope of CleanTech/cleaner technology. Focus will be on innovation and design processes
- **business models and general socio-economic conditions**

As *electives* in connection with the above it is possible to choose between a number of courses in 'systems analysis', which is a subject area with a series of associated tools for analysing the complex environmental contexts of the industrialised parts of the world with an environmental / a sustainable approach:

- **advanced life cycle assessment / systems analysis** – including especially consequential LCA. Connected to this course is a separate project module which focuses on various more advanced cases; either related to an energy system, a form of waste management, or as an analysis of different kinds of design for 'End of Life' (the course LCAII with associated case module).
- **Life cycle assessment / systems analysis applied on bioresources or biosystems** – focus is on the special challenges of operating in both the techno-sphere and the biosphere
- **mass-flow-analysis** in relation to waste management and waste systems – as a means to determine the flow of valuable minerals and other substances/materials
- **atmosphere chemistry focussing on global warming** – the transport phenomenon in the atmosphere and the stratosphere – as an example of a thorough analysis of the most important environmental impacts of today
- **risk analysis** as a tool for analysing unwanted/accidental impact of various manufacturing methods – including especially the use of various processing agents
- **security and environmental management** – as a management related supplement to the risk analysis course.

In relation to **waste** the following is compulsory

- **waste management** – to illustrate how mankind administer the extracted resources.

As *electives* students can choose:

- **methods/technologies for separating and processing waste** – in relation to ensuring that the resources are kept in circuit
- **industrial ecology / industrial symbiosis** as a conceptual supplement and link to biological systems where the resources are utilised through an intelligent interplay between companies.

Especially in relation to **water** the following is compulsory:

- **industrial water treatment and reuse** – as an example of a CleanTech area, which at the same time illustrates the complexity of developing and implementing new manufacturing technologies
- **process integration (Pinch analysis)** as a means to analyse mass and energy flow in companies and to identify recycling and recovery potential.

In relation to **energy** the following is compulsory:

- **energy system analysis** – focus is on analysing and optimising the complex interplay between the many different types of energy production of a highly industrialised society.

**PROGRESSION**

The academic progression of the programme is ensured with the constituent courses.

The above mentioned constituent courses constitute the backbone of this programme.

Based on a general understanding of the global challenges and the methods to analyse them through systems analysis (LCA) as well as methods to optimise the energy and material cycle of industrial systems (process integration) and methods for risk analysis, students concentrate on approaches and methods for optimising the water cycle in industry, optimising waste management in society as well as sustainable innovation and design.

Based on the above qualifications students work on systems and methods for management/control of management and development within the environment, security and health, and the disciplines of process integration, material flow analysis and waste and water characterisation are strengthened in the course industrial ecology/symbiosis.

The constituent course in scientific work methods forms together with the other theoretical and practical courses the basis for the thesis work.

If the thesis work include practical laboratory work it will often be appropriate to take advantage of the opportunity for a 40 ECTS master’s thesis.

## §6 Language

The common, constituent courses and profile constituent courses are offered in English. In courses where both all the students and the teacher are Danish, teaching may be conducted in Danish but course material will be available only in English.

## §7 Qualifying Exams for Admission

**1. Bachelors with automatic claim for admission**

Bachelors of Science (BSc) in Engineering (Chemistry)

Bachelors of Science (BSc) in Engineering (Chemistry) from the Department of Chemical Engineering, Biotechnology and Environmental Technology, SDU have an automatic claim for admission on the MSc in Engineering (Environmental Engineering) programme.

Bachelors of Science (BSc) in Engineering (Environmental Engineering)

Bachelors of Science (BSc) in Engineering (Chemistry) from the Department of Chemical Engineering, Biotechnology and Environmental Technology, SDU have an automatic claim for admission on the MSc in Engineering (Environmental Engineering) programme.

**2. Other qualifying bachelor exams from the University of Southern Denmark**

Bachelors in Engineering (Chemical Engineering), Bachelors of Science (BSc) in Engineering and Bachelors of Science (BSc) from SDU are immediately eligible for admission to the programme.

**3. Other qualifying exams**

Bachelors of Science and Bachelors of Engineering from other universities

Bachelors of Science and Bachelors of Engineering from other universities (Danish or foreign) are immediately eligible for admission to the programme, provided their academic background is scientific or technical. Other admission will be based on individual, academic assessment.

## §8 External Examiners and Study Board

The study programme belongs under the Academic Study Board of the Faculty of Engineering and the Danish corps of external examiners for engineering programmes. Modules offered by the Faculty of Science belong under the corps of external examiners for science.

## §9 Entry into Force

1. Approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 13 February 2014.

2. Amendments approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 23 June 2014 (Version 1.0).

3. Amendments approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 12 November 2014 (Version 1.1).