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Self-Assessment Report for International Accreditation – Bachelor's and Master's degree programmes in Energy Technology

Editors: Aija Kivistö, Esa Vakkilainen, Annikka Nurkka

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1 Formal Specification

1.1 Name of the degree programme and contact details

Name of the Degree Programme (Finnish)	Energiatekniikan koulutusohjelma - tekniikan kandidaatti - diplomi-insinööri
Name of the Degree Programme (English)	Degree Programme in Energy Technology - Bachelor of Science (Tech.) - Master of Science (Tech.)
Language of instruction	Finnish/English
Contact person	Professor Esa Vakkilainen esa.vakkilainen@lut.fi Mobile +358 40 357 8684 Fax + 358 5 621 6399
Web address	www.lut.fi

The site of execution of the Degree Programme in Energy Technology is the Department of Energy Technology at Lappeenranta University of Technology (LUT). The Department of Energy Technology belongs to the Institute of Energy Technology (LUT Energy) that operates under the administration of the Faculty of Technology. LUT Energy brings together the energy related education and research at Lappeenranta University of Technology. LUT Energy coordinates three degree programmes: Energy Technology, Electrical Engineering and Environmental Technology. LUT Energy is the largest education and research organisation in the energy sector in Finland.

1.2 Type

Studies are full time and take place on weekdays from 8 to 19. Courses can last from one to four periods. However, the university also offers courses as intensive courses, but Energy Technology does not currently offer any intensive studies as a part of the regular curriculum. Most modules are offered every year, but some of them are offered every second year. All the module details are given in the module descriptions available in the study guides. Attending lectures is not compulsory, but typically attendance facilitates passing. Courses use study and teaching portals Noppa and Blackboard which facilitate self-study and make distance learning a possibility.

1.3 Final Degrees

The degrees to be awarded are Bachelor of Science (Tech.) in Energy Technology and Master of Science (Tech.) in Energy Technology. The Universities Act (558/2009) (Appendix C1) and the Government Decree on University Degrees (794/2004) (Appendix C2) grant the right to award these degrees to Lappeenranta University of Technology. As a result of the implementation of the Bologna process in the Finnish Universities, the present degree structures have been effective since 2005.

1.4 Standard period of study and credit points gained (according to ECTS)

The extent of studies required for a lower university degree is 180 ECTS credits and for the higher university degree 120 ECTS credits. The university must arrange the education to enable the student to complete the lower degree in three years, and the higher degree in two years of full-time study (Appendix C2).

1.5 Expected intake for the programme

Faculty council makes a proposal to the rector on the student intake for faculty degree programme. The number of the expected intake through joint application is defined between the rector and the degree programme on yearly basis. During the last few years, the expected intake has been constant, Table 1.

There are several separate variants of entrance to the B.Sc. degree programme but all these allow the student to continue directly to the Master's degree programme without a separate application (see Joint application in Table 1). The Bachelor's degree programme includes applicants who have succeeded in specific competitions in the fields of mathematics and natural sciences, IB/EB applicants, students who have attended a specific forest industry study line in upper secondary school or have studied in the Open University. The International Master's degree programme with separate application is not included in the accreditation process.

Table 1. Expected intake of students

	Joint application	Separate application
2009	40	20(*
2010	40	25(*
2011	40	25(*

(* including the students in the M.Sc. degree programmes which are not included in the accreditation process; 19 students in 2009, 19 students in 2010, and 21 students in 2011.

1.6 Programme start date within the academic year and first time the programme is offered

The academic year of the university starts on 1 August and ends on 31 July. The academic year is divided into two semesters. The autumn semester (period 1 and 2) and the spring semester (period 3 and 4) each include two periods lasting seven weeks. The Degree Programmes in Energy

Technology can be commenced once a year in the beginning of the academic year. The courses being offered are coordinated to ensure this.

Education directed to Energy Technology has been offered since the university was founded in 1969. During the first years, the education was part of the studies in the Department of Mechanical Engineering. In the beginning of the 1970s, the Department of Power Plant Technology was founded as a separate entity, which later changed its name to the Department of Energy Technology. In 2005, the university changed its name to the current Lappeenranta University of Technology.

1.7 Amount and type of charges

Education leading to a university degree and the entrance examinations relating to student admission shall be free of charge for the student (Appendix C1).

The students of Lappeenranta University of Technology must register each academic year as attending or non-attending. Each student who wishes to take part in lectures, assignments, examinations or other forms of teaching must register as attending and pay the Student Union membership fee 103 €/a. This fee covers, for instance, the health care of the students.

2 Degree Programme: Content, Concept and Implementation

2.1 Aims of the programme of studies

The strategic areas of expertise in the Lappeenranta University of Technology are the energy efficiency and the energy market (Appendix C3). The educational objectives of the Degree Programme in Energy Technology reflect the mission of Lappeenranta University of Technology. Energy Technology covers the technology and systems needed in energy generation, transmission, distribution, and utilisation.

As a result of the implementation of the Bologna Process in the Finnish Universities, the present two cycled degree structures have been effective since 2005. All students have so far continued in the degree programme of Master of Science (Tech.) after the degree of Bachelor of Science (Tech.) which has actually been the norm in the Finnish universities of technology. The degree of Bachelor of Science (Tech.) is currently almost unknown to the potential employers, so the requirement of the Bachelors of Science has been nonexistent. The objectives of the Bachelor's and Master's degree programmes will be available in the study guide for the academic year 2012-2013 published on the webpage of the university. The study guide for the academic year 2011-2012 is in Appendix EN1. Courses offered by other degree programmes which are included in the Bachelor's and Master's degree in Energy Technology are also described in Appendix EN1.

2.1.1 Aims of the Bachelor's Degree Programme in Energy Technology

The degree programme in Energy Technology offers the students possibilities to acquire competences required in positions where energy technological expertise is expected, within different operation sectors of the society. The objective of the degree programme is that the students will demonstrate adequate knowledge of various power plant types, including their safety and optimisation, and of the components related to energy processes. The common thread throughout the degree programme is the energy-efficiency and environmental friendliness.

The B.Sc. degree programme in Energy Technology provides the students with skills to consider the application possibilities of all energy forms within various application sectors, e.g. in energy production, in the heating of buildings, in processing industry, within the electrotechnical field, and in transport services.

Central professional objectives include the following:

- knowledge of the scientific and mathematical fundamentals related to energy conversion, transfer, distribution, and utilisation, including their most essential applications,
- qualifications for the conventional tasks within the field of energy technology and the ability to develop the field, including the ability to continue to Master's studies, and
- knowledge of the effects of technological solutions within energy management on the environment.

2.1.2 Aims of the Master's Degree Programme in Energy Technology

Comprehensive expertise within the field of energy technology is a trademark which the degree programme in Energy Technology wishes to grant every graduating Master of Science. The graduates are able to develop their professional competence to be able to work in the highest positions dealing with energy technology in industry, solution providers or officials.

Central professional objectives include the following:

- general view on the effects of technological solutions within energy management on the society and the environment,
- understanding of economical basics within societal energy management,
- knowledge of special issues focusing on environmental and energy technology within the fields of domestic manufacturing, export industry, building trade, and municipal and national sectors,
- integration of theoretical knowledge and practical data management systems by mastering the models and methods within the chosen field, and
- the ability to develop the chosen field, including the ability to continue to post-graduate studies.

2.2 Learning outcomes of the programmes

Learning outcomes for the Degree Programme in Energy Technology are defined separately for the Bachelor's and Master's degrees. The learning outcomes for the degrees will be published in the next study guide for the academic year 2012-2013 and it will be available on the LUT web site. The current study guide will be updated in spring 2012.

Professors of the degree programme and course teachers have participated in the definition of the learning outcomes. The requirements of the labour market are transmitted into the definition the learning outcomes of the degree programmes through research projects. Also the requirements of the post-graduate studies have been taken into account in the definition of the learning outcomes.

The correspondence of the ASIIN subject specific criteria and the learning outcomes of the degree programme has been examined in Appendix EN2. There are no Technical Committee and subject specific Criteria (SSC) for Energy Technology. The Technical Committee 01 for mechanical/process/chemical engineering was chosen because the learning outcomes of the B.Sc. and M.Sc. degrees according to ASIIN's subject-specific criteria of TC01 suited best the learning outcomes of the degree programmes of Energy Technology.

An overview of the degree programmes is compiled for curricular analysis (Appendix EN3). The Curricular Analysis is performed according to the criteria for Process Engineering, Biological, and Chemical Engineering. Each course is classified into curricular categories.

2.2.1 Learning outcomes of Bachelor's Degree

The learning outcomes for the graduates of the B.Sc. degree programme are defined as follows. After the completion of the Bachelor's Degree Programme in Energy Technology the student can:

- describe the physical basic phenomena related to energy technology,
- apply the basic equations of thermal engineering in the examination of energy conversion related processes,
- describe the structure and operation principle of the equipment related to energy technology (boilers, turbines, compressors, fans, heat exchangers),
- calculate operating values of the equipment and define their measurement principles,
- describe the operation principles of various energy conversion processes,
- compare the applicability of various energy conversion processes to different applications from technological, economical, and environmental perspectives,
- acquire information from various sources and evaluate their quality and reliability,
- communicate both orally and in writing in an international environment, and
- work in projects as an expert in the field of energy technology.

All students in the Bachelor's Degree Programme in Energy Technology have the same major subject, Energy Technology.

Major subject: Energy Technology
After completing the major subject studies in Energy Technology, the student knows the theoretical and practical fundamentals in energy technology within the fields of power plant technology, combustion technology, and process equipment technology, and has a holistic view of the energy production processes, methods, and equipment. The goal of the education is to provide the student with skills to deepen his/her expertise in the technology related to energy production, transfer, and utilisation in the Master's degree programme.

Minor Subject

The minor subjects in the Bachelor's Degree Programme in Energy Technology are Environmental Technology and HVAC Engineering offered by the degree programme of Environmental Technology. In the Bachelor's degree, the student may choose his/her minor subject also from other degree programmes.

Minor Subject 1: Environmental Technology
The minor subject in the Bachelor's Degree Programme in Environmental Technology provides the students with both theoretical and practical knowledge and skills within the field, concentrating on the technology related to energy production and utilisation. The minor studies contain the basic knowledge of technology, management, law, and economics within the field. The minor subject entity provides the students with knowledge and skills to operate in jobs requiring expertise in the environmental effects of energy production and utilisation (e.g. in design or product development).

Minor Subject 2: HVAC Engineering
The minor subject in HVAC (Heat, Ventilation, Air Conditioning) Engineering provides the students with knowledge and skills to design and dimension HVAC systems with the aim of appropriate operational conditions. The students will acquire both theoretical knowledge and practical skills in HVAC engineering and the ability to analyse the elements affecting energy use, environmental load, and costs of buildings. The minor subject entity provides the students with knowledge and skills to operate in jobs requiring expertise in HVAC Engineering (e.g. in planning or product development).

2.2.2 Learning outcomes of Master's Degree

The learning outcomes for the graduates of the M.Sc. degree programme are defined as follows. After the completion of the Master's Degree Programme in Energy Technology the student can:

- analyse, design and select energy conversion processes for different applications, taking technological, economical, environmental and societal aspects into account,
- apply and develop mathematical models to solve energy technological problems,
- manage and organise both national and international projects, and
- communicate and act in academic and research environments.

All students in the Master's degree programme in Energy Technology have the same major subject, Energy Technology.

Major subject: Energy Technology

The student concentrates on machines and process technologies related to energy production and utilisation. Key subject areas in the major subject are power plant engineering, nuclear engineering, energy economy, energy machines and processes, environmental technology related to energy processes, energy efficiency, and renewable energy sources. The objective of the education is to provide the students with skills to operate in positions in energy technology industry and production, including development, operating, and process engineer positions within related branches.

Minor subject

The minor subject in the Master's degree programme must be chosen from the following six minors offered by the degree programme in Energy Technology. In minor subject studies the student specialises in one energy technology field.

Minor subject 1. Energy Economy

The student concentrates on the selection criteria of energy production, cost calculations, calculations of energy scenarios, carbon dioxide emission calculations, the effect of emission trading on the price of energy, electricity market price determination principles, and energy economy in forest industry. The objective of the education is to train experts specialised in energy economy with skills and knowledge to operate in research, development, design, and operating positions both in companies and public sector organisations, within energy and energy-intensive sectors.

Minor subject 2. Energy Machines and Processes

The student concentrates on various machines related to energy conversion, such as turbines, windmills, compressors, and pumps, including their properties, as well as their optimisation and design. The objective of the education is to provide the students with knowledge and skills to operate as development, operating and process engineers focusing on energy machines and processes within the fields of energy technology and the related supplier branches.

Minor subject 3. Power Plant Engineering

The objective of the education is to familiarise the student profoundly with thermal power stations and their design, construction, systems, and operation. After completing the minor subject studies, the student has good knowledge of the different methods of heat and power generation, ranging from fuel characteristics to heat and power distribution. Also the distribution systems and consumer equipment of both district heating and natural gas are included in the topics of the minor subject. The student understands the cost structure of heat and power generation and the management of the emissions generated in the processes. The minor in Power Plant Engineering provides the student with excellent skills to function in operating, maintenance, design and research positions in power plant, as well as in energy technology related companies, engineering offices, and research institutes. The minor provides the students with theoretical knowledge required of a person responsible for the operation of pressure equipment.

Minor subject 4. Nuclear Engineering
The student is provided with diversified skills to operate in positions within the nuclear field; in power plants, engineering offices, nuclear waste management and research institutes, as well as in nuclear authorities and power plant suppliers. The student understands the operation principles of a nuclear power plant, including their operational safety, reliability, and optimisation. A student who has obtained 20 ECTS credits either by completing courses or his/her Master's thesis in one of LUT's international co-operation universities, has a possibility to acquire a European nuclear certificate (ENEN).

Minor subject 5. Modelling of Energy Systems
At present, numerical modelling is an increasingly employed tool in the design of various energy technology related processes and machines. The minor familiarises the students with the modelling of energy related processes by using both existing software used within industry and research and self-made tools. The student familiarises him/herself with the used models and is able to apply them into existing or potential industrial problems. The minor provides the students with excellent skills to operate in research and development and design positions within industry.

Minor subject 6. Sustainable Energy Production
The student familiarises him/herself profoundly with renewable energy, especially with wind and solar power, in order to be able to operate in research and development and design positions within the industry related to sustainable energy production. The minor familiarises the students with the construction and building of wind power stations, the project management of renewable energy power plants, and the conversion of wind energy. The minor also familiarises the students with further renewable energy production forms, like solar heat, solar power, tidal power, and geothermal energy, including their production and investment costs. The student also learns to manage the environmental effects and reliability of their utilisation, including the special solutions related to the characteristics of the production forms.

2.3 Learning outcomes of the modules

The learning outcomes of the programme are put into practice within the individual courses of the programme. The learning outcomes for individual courses are defined in the study guide 2011-2012 (Appendix EN1) which is available on the university web pages. The descriptions of learning outcomes of the courses are written by teachers of courses. LUT Teacher's Quality Manual (Appendix C5) was used as help to describe knowledge, skills and competences acquired in the courses. The latest results of the research are taken into account in teaching, because most of the researchers act also as teachers.

The contribution of the individual course in learning outcomes of the programme is indicated in the Objective Matrix (Appendix EN4). The B.Sc. degree and M.Sc. degree are described separately. The courses' contribution within the learning outcomes of the programmes were classified with terms low (L), average (A), and high (H). Teachers of the courses participated in the description and classification work.

The B.Sc. degree in Finland is primarily considered as a way to M.Sc. degree studies, introducing students to the scientific thinking and methods. The B.Sc. degree starts with general studies, e.g.

mathematics and physics, the portion of which is significant in the first study year. According to ASIIN's criteria, the B.Sc. degree in Energy Technology consists of (Appendix EN3):

- 22 % mathematic-scientific fundamentals,
- 15-18 % engineering fundamentals,
- 10-11 % subjects in process engineering,
- 10-13 % engineering applications,
- 11 % subjects in engineering for the creation of focal points of studies,
- 7-12 % cross-subject studies,
- 6 % Bachelor's Thesis, and
- 1 % practical training.

The portion of elective studies is 8-10 %. The student may include any courses taught at LUT in the elective studies. The variation in some criteria is caused by the selection of minor subject. The student chooses his/her minor subject from other degree programmes.

According to ASIIN's criteria, the M.Sc. degree consists of (Appendix EN3):

- 50-52 % advanced fundamentals and application of mathematic, natural and engineering sciences,
- 8 % cross-subject contents,
- 25 % Master's Thesis, and
- 2 % practical engineering activity.

The portion of elective studies is 14-16 %. The student may include any courses taught at LUT in the elective studies.

2.4 Job market perspectives and practical relevance

The fields of education of the Finnish universities are defined by the Ministry of Education and Culture. The Board of Lappeenranta University of Technology decides the total number of new entrants. The contents of the degree programmes are decided by Faculty Council.

In the Degree Programme in Energy Technology, the content of the Degree Programme is determined on the basis of the general requirements concerning the education of energy engineers, and the needs and expectations of the energy industry. The industrial cooperation carried out in the research project provides a forum of information exchange about the needs and expectations of the industry regarding the education of energy technology.

According to the report of Finnish Energy Industries (Energiateollisuus ry) published in 2010, energy efficiency knowledge is estimated to belong to the core competencies of more and more experts within the energy field (Job Market in Energy Field in 2020, scenario, in Finnish). Additionally, the amount of employees within the energy field will increase during the next decade, and the increase will be the highest among engineering professionals. The proportion of university graduates will increase, because the increasing renewable energy sources require new knowledge and skills in the companies within the energy field. Especially within the nuclear power field, the need for university graduates will grow, because in Finland building licences have been awarded to two new nuclear power plants. Another reason for the growing need for personnel is the age distribution of the employees which is reflected especially strongly in the need for the experts within the nuclear energy field. The Advisory Committee on Nuclear Energy of the Ministry of Employment and the Economy has also estimated that the need for experts who have acquired

a specialised education within the nuclear energy field will grow. Energy technology has also traditionally educated most of the engineers responsible for energy generation in the forest industry. The Finnish boiler manufactures Andritz, Foster Wheeler, and Metso employ a large portion of the graduates.

The courses in the Degree Programme involve laboratory and project work as well as practical training in order to provide an adequate connection to the professional practice and to prepare the students to commence work in existing or foreseeable professional fields. The courses in the degree structure are also closely linked to the research conducted in the department and provide a path to post graduate studies. Moreover, a large majority of Bachelor's and Master's theses are completed in cooperation with industry in various projects either at the university or in companies, and thus provide a link to the professional field and a path to future employment in specialist tasks in these research areas.

Practical training is included both in the Bachelor's and Master's degree. The total value of obligatory practical training is 2 ECTS credits both in the Bachelor's and Master's degree. In addition to the obligatory practical training, the student has a possibility to include max 8 ECTS credits of practical training in the elective studies of the Master's degree (see Appendix EN1 Study Guide page 11).

In the Bachelor's degree, all work assignments can be included in the work environment training. This practical training has a more general purpose. After completing the work environment training, the student is able to define and explain, what it is like to be working as an employee, and what are the basic rules in working life from the view of an employee.

The practical training in the Master's degree studies is carried out in student's own professional field. After completing the practical training, the student is able to use and generalise the knowledge and skills he/she has obtained on various courses in practice in his/her own field. The student acquires practical experience and skills of the work assignments, production equipment, and software. Typical tasks include for example assignments related to planning, research and development, production, and operation. Also various research tasks are suitable for the practical training in the Master's degree, as well as working in supervisory positions.

2.5 Admissions and entry requirements

2.5.1 Entry requirements for Bachelor's degrees

Finnish Universities Act (558/2009, 37§)(Appendix C1) rules the entry requirements for the Bachelor's degree. According to the Finnish Universities Act, the board of the university decides the number of new students to be selected each year. Rector decides annually the selection process and basis of the selection criteria of the prospective students after hearing the opinion of the faculties. In practice student selection into the Bachelor's degree for Finnish matriculation examination graduates is mainly organised by a joint universities application system, DIA (joint-application to Studies of Bachelor and Master of Science in Technology). This joint application system is common for seven technical universities in Finland. The joint application system is coordinated by a joint application committee. This process enables an applicant to apply for five degree programmes in order of preference in one or in several technical universities using the same application form and examinations. The applicant is given up to 3 points for the programme he/she has prioritised. The application system enables prospective students to apply for several degrees at the same time. The applicant is able to accept only one student place in degree education in a given academic year.

Prospective students applying in the Bachelor's degree in technical universities are:

- Applicants who have completed the Finnish matriculation examination or who have completed the Finnish matriculation examination and received a blue certificate.
- Applicants who have completed the EB, IB (European and International Baccalaureate) or Reifeprüfung degree (from die Deutsche Schule Helsinki).
- Applicants who will complete the EB or IB or Reifeprüfung degree either in Finland or abroad during the application year. These applicants must include their degree certificate or a certificate of participation in the respective examination from their school with their application form.
- Applicants who are not upper secondary school graduates but who have completed a polytechnic higher vocational degree, vocational polytechnic degree or at least a three-year vocational degree.
- Applicants from other Nordic countries who are eligible for application.
- Applicants who have not completed upper secondary education in Finland are eligible to apply for Bachelor's degree courses if they are eligible for to study at a university in their own country.

DIA applicants have three different quotas where they can be selected in: 1. Success in matriculation examinations; 2. Success in matriculation examinations and in the entrance examinations; and 3. Success in entrance examinations. To be selected by success in matriculation examination, the prospective student must have at least grade C in physics or chemistry and passed advanced course in mathematics or he/she must have at least M in advanced course in mathematics. Six best grades in matriculation examinations are graded as points which count in the selection process. 50 % of the applicants accepted into degree can be selected based on their success in the matriculation examination. DIA organizes also this selection. The results are communicated to the applicants before the entrance examinations and students accepted based on their success in the matriculation examination are not allowed to participate in the entrance examinations. 70 % of the remaining study places are selected based on the success in the

matriculation examinations and entrance examinations. In this case, the success in six examinations in matriculation examinations counts along with the points received in the entrance examinations.

The entrance examinations are organized by the joint application procedure. The entrance examination is based on the Finnish upper secondary school curriculum in mathematics, physics and chemistry. There are three separate examinations. Prospective students must pass the entrance examination to be selected even if there are fewer applicants than places attained. This guarantees minimum knowledge level in science of all selected students. There are no extra aptitude tests in the Bachelor's degree.

Other applicants, meaning applicants who have performed their matriculation examinations abroad, have a separate application system, but they take part to the same entrance examinations as the DIA applicants.

Information about applicants is available according to the Finnish law of student selection register (1058/1998). Prospective students are able to apply in the Internet at www.yliopistohaku.fi. A prospective student has eligibility to appeal against the negative result of student selection within 14 days of the decision.

There are several specialised variants of the higher education entrance in the Bachelor's degree programme in Energy Technology:

- Prospective students who have succeeded in defined competitions;
- IB/EB applicants;
- Prospective students who have performed forest industry line METELI in upper secondary school; and
- Studies in the Open University (after performing 30 ECTS including 16/19 ECTS mathematics and 5 ECTS physics, average grade at least 2.0).

These all special cases are considered and the selection process is presented on the Internet pages of LUT.

Students applying in the Bachelor's degree are not supposed to have any former work experience or industrial placements; neither do they help in the applying process for the Bachelor's degree.

Bachelor's degree courses are fully taught in Finnish, and thus very good Finnish skills are required. If the applicant has received education outside Finland, and he/she is a non-native Finnish speaker, proficiency in Finnish has to be demonstrated. General language degree in Finnish at level 4 or above (max. level 6) is accepted.

2.5.2 Entry requirements for Master's degrees

All students accepted in the Bachelor's degree programme are also accepted in the Master's degree programme in the same field of engineering. The Master's thesis project cannot be commenced (the topic of the thesis cannot be applied for) before completing the Bachelor's degree.

If a student wants to change the field of engineering (e.g. from Mechanical Engineering to Energy Technology) after finishing his/her B.Sc. degree, he/she can: 1) change the programme; or 2) apply to a separate Master's degree programme. These Master's degree programmes are not included in this accreditation process.

Student can request for a change of the degree programme after completing the Bachelor's degree. If there are more requests than the degree applied is willing to take, quantitative and qualitative success in studies can be used as measure.

Master's degree courses are taught mainly in Finnish, and thus very good Finnish skills are required. The students are also supposed to have good English skills, as additional materials provided during the courses are often in English. The Master's degree programme can also contain courses wholly organised in English.

Applicants who have obtained their compulsory education in a language other than Finnish shall provide a certificate of their language proficiency in the Finnish language. Sufficient proof of language proficiency can be demonstrated by completing the National certificate of Language Proficiency test at level 4 or above (= intermediate level, 6 being the highest). Applicants whose mother tongue is Finnish are exempted from this requirement.

2.6 Curriculum/content

The target of the curriculum work process is the production of a high-level curriculum in terms of both content and communication. The curriculum lays the foundation for teaching and the planning (individual study plans) and implementation of studies. The vice-rector for education and Heads of degree programmes are responsible for the curriculum work.

The curriculum work ensures the production of high-quality degrees: the expertise obtained from the degree studies is based on current, key research-based knowledge in the field of science in question, and on the development of general competencies as a part of the degree. The curriculum work takes into account the expertise required in the increasingly diverse and international world of work and the perspective of lifelong learning. Degree programmes collaborate in curriculum work in order to secure synergy benefits as extensively as possible.

The objectives of degree programmes and courses are defined as learning outcomes. The learning outcomes of modules and courses are based on the mission of a given degree programme. Descriptions regarding instruction (e.g. learning outcomes and number of ECTS credits) follow regulations and are realistic.

The process results in degree programme and course descriptions, which are published annually in the study guide on the university web site. Publication is coordinated by the Student Affairs Office.

The quality of the process is evaluated by examining the curriculum process and degree programme development. The quality indicators for the curriculum process are: the continuous development and professional relevance of curricula and degree structures, true-to-life course descriptions that follow guidelines and the publication of the study guide on schedule. Changes to study guide are handled by the faculty councils.

The executive group and the advisory group managed by the Head of the degree programme make curriculum work processes in the degree programme. The professors, study coordinator and students belong to the groups.

3. Degree Programme: Structures, Methods and Implementation

3.1 Structure and modularity

The Degree Programme in Energy Technology comprises two cycles, and its standard duration is five years. The first cycle takes three years and leads to a Bachelor's degree. The second cycle leading to a Master's degree takes two years.

3.1.1 Bachelor's Degree

The structure of Bachelor's Degree Programme in Energy Technology is illustrated in Figure 1. The Bachelor's studies start with general studies which include for instance mathematics, physics, language and communication studies, studies in energy technology, and practical training.

All students in the Degree Programme in Energy Technology have the same major subject; Energy Technology. The Bachelor's thesis and a seminar (10 cr) are included in the Major Subject.

<table>
<tr><th colspan="2">BACHELOR OF SCIENCE 180 ECTS cr (1.–3. year)</th></tr>
<tr><td colspan="2">A. General studies 102 cr
General scientific skills 71 cr
General skills provided by the Degree Programme 31 cr</td></tr>
<tr><td>B. Major Subject 40 cr</td><td>C. Minor Subject 20 cr (min)</td></tr>
<tr><td colspan="2">D. Elective studies 10 cr (min)</td></tr>
</table>

Figure 1. Bachelor's degree in Energy Technology.

The minor subjects in the Bachelor's Degree Programme in Energy Technology are Environmental Technology and HVAC Engineering offered by the degree programme of Environmental Engineering. In the Bachelor's degree the student may choose his/her minor subject also from other degree programmes. Especially the minor subjects in Electrical Engineering and Mechanical Engineering are recommended to the students of the degree programme in Energy Technology.

3.1.2 Master's Degree

After completion of the Bachelor's studies, the student continues his/her studies in the Master's degree programme. In the Degree Programme, the structure of the Master's studies is illustrated in Figure 2.

The Master's degree programme consists of general studies including for instance mathematics, language and communication skills, and practical professional training. The major subject for all students is Energy Technology. The Master's thesis (30 cr) is included in the Major Subject.

The minor subject in the Master's degree programme must be chosen from the following minors offered by the degree programme in Energy Technology: Energy Economy, Energy Machines and Processes, Power Plant Engineering, Nuclear Engineering, Modelling of Energy Systems, and Sustainable Energy Production. In the minor subject studies the student specialises in one energy technology field.

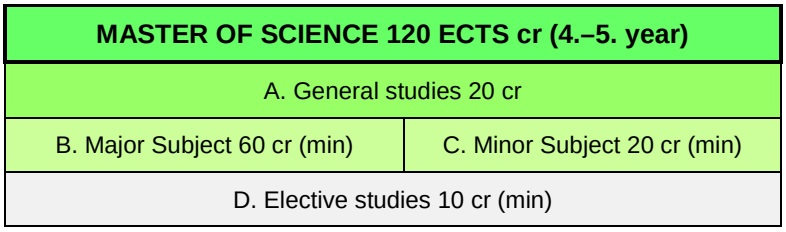

Figure 2. Master's degree in Energy Technology.

The programme structure, the courses of the degrees and course sizes (duration and number of ECTS credits) are described in detail in the study guide (Appendix EN1).

3.1.3 Elective studies and practical training in B.Sc. and M.Sc. degree in Energy Technology

The student must take a suitable amount of elective studies to reach the total of 180 ECTS credits required for the Bachelor's degree and the total of 120 ECTS credits required for the Master's degree. The student may include any courses taught at LUT, also another minor subject in his/her Bachelor's degree. Studies in other domestic or foreign higher education institutions can be included in the degree by application; the studies are approved by the Head of Degree Programme. The leadership training provided by the National Defence Forces can be included in the elective studies (6 ECTS cr) provided that these studies are not included in any previous degree.

Practical training is included both in the Bachelor's and Master's degree. The total value of obligatory practical training is 2 ECTS credits both in the Bachelor's and Master's degree. In addition to the obligatory practical training, the student has a possibility to include max 8 ECTS credits of practical training in the elective studies of the Master's degree. The student acquires a job for practical training in a company or at the university, and it is completed in summer time. The training will be approved by the reviewer of the training applications. More detailed description on practical training is in the study guide on page 11 (Appendix EN1).

3.2 Workload and credit points

The basic unit of the studies is one credit point. A course is scored by the workload required to pass it. To complete the studies of one academic year requires on average 1600 hours, which corresponds to 60 ECTS credits (Appendix C2).

One credit point equals to approximately 26 hours workload, including face-to-face teaching hours, individual studying, as well as preparation for and taking part in the examinations. Obligatory industrial training of 2 ECTS credits is required for the Bachelor's and Master's degrees, respectively. For training, one ECTS credit equals to two week's working as an employee. The employee contract has to be at least for 15 days.

The study guide presents how the tuition is divided between the study years. The scheduling of courses is planned accordingly.

The Degree Programme is composed so that by following the study guide (Module Handbook), the degrees can be completed within the standard period of study (i.e., it is possible to take 60 credits per year on average), and the maximum of 75 credits is not exceeded in any year (Appendix EN5).

If a student conducts studies in another university or educational institute in Finland or abroad, he/she can request the head of the degree programme to credit the studies taken elsewhere. A student can credit and replace study modules also by knowledge gained otherwise. Knowledge can be proved e.g. by an oral or written examination or portfolios. Still, at least 90 ECTS credits of the Bachelor's degree (including the Bachelor's Thesis) and 70 ECTS credits of the Master's degree, including at least 45 ECTS credits of major subject studies, including the Master's Thesis, have to be passed at LUT.

3.2.1 Workload and credit points in Bachelor's Degree

The workload for the Bachelor's degree is presented in Table 2. The detailed workload analysis can be found in Appendix EN5. The academic year consists of four periods. The elective studies are not included to the workload analysis in Table 2, because the student can choose any courses taught at LUT to the elective studies according to his/her interest. The elective studies are recommended to be conducted in B.Sc.2 or B.Sc.3 on the basis of the workload analysis. The Bachelor's thesis and seminar (10 ECTS cr) is scheduled to the periods 3 and 4 in B.Sc. 3. Language studies are scheduled in the year B.Sc.3 (4 ECTS cr), 1 ECTS cr for each period. Because the practical training (2 ECTS cr) is usually completed in the summer time, the workload is included to the summary credits of the B.Sc.2.

Table 2. Workload per the year of study and periods, Bachelor's degree

		Major subject: Energy Technology				
		ECTS cr	**1 per.**	**2 per.**	**3 per.**	**4 per.**
General Studies (GS) and Major Subject (MS)	B.Sc. 1, obligatory studies	62	15,5	14,5	15,5	16
	B.Sc. 2, obligatory studies	32	4,5	4,5	11	10
	B.Sc. 3, obligatory studies	48	11	7	19	11
	Summary, obligatory studies	**142**	**31**	**26**	**45,5**	**37**
GS + MS + Minor Subject 1: Environmental Technology	B.Sc. 1, obligatory studies	65	17	16	15,5	16
	B.Sc. 2, obligatory studies	49	7	11	14	15
	B.Sc. 3, obligatory studies	48	11	7	19	11
	Summary, obligatory studies	**162**	**35**	**34**	**48,5**	**42**
	Elective studies	**18**				
GS + MS + Minor Subject 2: HVAC Engineering	B.Sc. 1, obligatory studies	65	15,5	14,5	18,5	16
	B.Sc. 2, obligatory studies	39	4,5	4,5	14,5	13,5
	B.Sc. 3, obligatory studies	60	14,5	10,5	24	11
	Summary, obligatory studies	**164**	**34,5**	**29,5**	**57**	**40,5**
	Elective studies	**16**				

Studies in other domestic or foreign higher education institutions can be included in the degree by application approved by the Head of Degree Programme. More detailed description of the credit point system and inclusion of studies in other institutions has been presented in the University Regulations on Education and the Completion of Studies (Appendix C4).

3.2.2 Workload and credit points in Master's Degree

The workload for the Master's degree is presented in Table 3. The detailed workload analysis can be found in Appendix EN5. The general studies, major subject and minor subject Sustainable Energy Production include elective studies which the student must choose from the list. The elective studies which can be any courses taught at LUT are not included to the workload analysis in Table 3, because the student can choose the courses according to his/her interest.

Table 3. Workload per the year of study and periods, Master's degree

		Major subject: Energy Technology				
		ECTS cr	**1 per.**	**2 per.**	**3 per.**	**4 per.**
General Studies (GS) and Major Subject (MS)	M.Sc. 1, obligatory studies	46	11	12	12,5	8,5
	M.Sc. 2, obligatory studies	35	5	0	15	15
	Summary, obligatory studies	**81**	**16**	**12**	**27,5**	**23,5**
GS+MS+Minor subject 1: Energy Economy	M.Sc. 1, obligatory studies	66	19	12	20	13
	M.Sc. 2, obligatory studies	35	5	0	15	15
	Summary, obligatory studies	**101**	**24**	**12**	**35**	**28**
	Elective studies	**19**				
GS+MS+Minor subject 2: Energy Machines and Processes	M.Sc. 1, obligatory studies	59	15	12	20,5	9,5
	M.Sc. 2, obligatory studies	44	11,5	2,5	15	15
	Summary, obligatory studies	**103**	**26,5**	**14,5**	**35,5**	**24,5**
	Elective studies	**17**				
GS+MS+Minor subject 3: Power Plant Engineering	M.Sc. 1, obligatory studies	52	15	12	13,5	9,5
	M.Sc. 2, obligatory studies	49	14	5	15	15
	Summary, obligatory studies	**101**	**29**	**17**	**28,5**	**24,5**
	Elective studies	**19**				
GS+MS+Minor subject 4: Nuclear Engineering	M.Sc. 1, obligatory studies	68	13	20	18,5	14,5
	M.Sc. 2, obligatory studies	35	5	0	15	15
	Summary, obligatory studies	**103**	**18**	**20**	**33,5**	**29,5**
	Elective studies	**17**				
GS+MS+Minor subject 5: Modelling of Energy Systems	M.Sc. 1, obligatory studies	63	17	18	15	11
	M.Sc. 2, obligatory studies	39	5	0	17	17
	Summary, obligatory studies	**102**	**22**	**18**	**32**	**28**
	Elective studies	**18**				
GS+MS+Minor subject 6: Sustainable Energy production	M.Sc. 1, obligatory studies	60	16	12	19	11
	M.Sc. 2, obligatory studies	41	8	3	15	15
	Summary, obligatory studies	**101**	**24**	**15**	**34**	**26**
	Elective studies	**19**				

The elective studies are recommended to be conducted in M.Sc.2 on the basis of the workload analysis. The Master's thesis and seminar (30 ECTS cr) is scheduled in the periodis 3 and 4 in M.Sc. 2. Language studies are scheduled in M.Sc.1 (4 ECTS cr), 1 ECTS cr for each period. Because the practical training (2 ECTS cr) is usually completed in the summer time, the workload is included to the summary credits of M.Sc.1.

3.3 Educational methods

The teaching methods applied in the Degree Programme in Energy Technology include lectures, classroom and laboratory exercises, assignments, project work, and seminars. The courses also involve group work which trains the social competences of the students. Computer-based Blackboard and Noppa learning environments are widely used in the courses. The teaching methods are chosen so that the student has time for self-study. As an average the student has 3 hours of independent study per one contact teaching hour. If the final thesis, which is mostly self-study, is not included, the coefficient is 2,4. The calculation of the self-study and contact hours for each course is presented in Appendix EN6.

In the Degree Programme, practice-oriented, problem-based learning are applied in some courses. The System Engineering method approach is used in the planning of energy systems.

To support the educational activities, the University publishes the Teacher's Quality Manual (Appendix C5) that provides the teaching staff with guidance, for instance, on the following issues:

- *Teaching planning*
- *Defining learning outcomes of a study course*
- *Determining the content of a study course*
- *Deciding the appropriate methods to evaluate the achievement of the learning outcomes*
- *Selecting suitable methods of teaching*

The Teacher's Quality Manual is designed to improve the quality of higher education and is available to all teaching staff at the University.

The student has a possibility to impact the content of his/her studies by choosing the subject of an assignment and the final thesis according to his/her interests. In general the student acquires the topic of his/her Master's thesis from companies or research projects of the degree programme. The topic of the Bachelor's thesis the student can acquire himself/herself from companies or write from the topic given by the professor of choice. In addition to the minor subject selection, the student may direct the contents towards his/her goals in work.

3.4 Support and advice

The university offers academic guidance actions that together cover the entire span of studies and efficiently support studies and learning. With this guidance, students are able to complete their studies by following an appropriate study plan that they have prepared themselves and to graduate within the desired time. There are also university and faculty level common instructions

available for the writing of the theses. The final thesis instructions are presented in Appendix C7. The roles and duties of study guidance personnel and units are listed in Table 4 below.

Table 4. Academic Guidance Methods

Peer tutor	Introduces new students to the university, studies and the student community, and helps them with practical arrangements at the start of studies. A peer tutor introduces new students to the university facilities, study guidance staff and other students. A peer tutor makes sure that students know the most important practices related to studies: registration for courses, attending lectures, taking examinations, preparing a course schedule, social aspects.
Tutoring coordinator	Coordinates and develops the university's peer tutoring together with faculties, Student Services and the student union.
Student adviser	Student advisers are LUT students who work part-time while they study. They provide information and guidance in studies, see to the choice of tutors and arrange their training together with the study coordinator and take part in arranging briefings for students.
Study counselling psychologist	Counsels students in problems related to studies and learning and provides expertise in issues involving learning and guidance, supporting other study guidance personnel.
Study coordinator	Coordinates study guidance for students. The duties include study and degree guidance for students, from applicants to postgraduate and partly even mature students. The study coordinator helps students in preparing their individual study plan (including the recognition of prior learning and studies outside LUT, e.g. through the flexible right to study) and provides guidance in administrative issues related to graduation.
Head of degree programme	Is in charge of evaluating and developing study guidance. Grants acceptance of courses not offered by the university.
Head of study affairs	Is responsible for organising study guidance in the faculty. Is responsible for administration of studies and partly also for study guidance related to administrative affairs.
Teacher/tutor	Helps students prepare their individual study plan and follow its progress. Teacher/tutors provide guidance in the selection of major and minor subjects from the viewpoint of career guidance. They are study guidance personnel appointed for a department or degree programme. Students may turn to them with any issues involving studies.
Teachers	Are responsible for study guidance related to the completion of the courses/modules they are responsible for.
Introductory course/module	Introductory courses are arranged in all degree programmes to help students get started with their academic studies. Introductory courses usually also guide in preparing an individual study plan.
Professors	Provide guidance in the selection of a research topic, and in preparing final theses for undergraduate and postgraduate studies.
International Services	Offers general study guidance to international students at the university and coordinates the activity of international tutors. International Services also assists Finnish students in matters related to studies abroad.
Career Services	Guides students in career planning and searching for employment.
Language Centre	Offers study guidance related to language, communication and culture studies.
Library	Provides guidance in information retrieval and instruction in information literacy.
Origo helpdesk	Supports services for the use of information and communication technology in studies.

At the beginning of their studies, students prepare an individual study plan (HOPS) on the Introductory Course. The study plan is made for the entire duration of the studies, i.e. until the M.Sc. degree is completed. An independent study plan is a tool that helps the students plan their studies. Its purpose is to help students to see their studies as a whole from the very beginning, and to support students in choosing courses and minor subjects that best suit them. The aim is also to avoid delaying graduation unnecessarily. It also awakens students to realise their own responsibility for their studies, and motivates and incites them to make a commitment to their studies. Examples of study plans for B.Sc. and M.Sc. degrees are enclosed in Appendices EN7 and EN8. Based on the individual study plan drawn by the student, in the degree programme in Energy Technology, the student and the teacher adviser will have a discussion on the plan.

Teacher advisers are experts of the various fields in energy technology who provide the students with content related tutoring regarding the individual study plan.

Teachers are responsible for the courses they teach, as well as supervision concerning contents of their own subjects. Persons in charge of the courses are required to have a doctorate. Teachers are available at the university mainly during office hours, but students may have guidance and individual supervision also out of these hours by fixing the time with the teacher.

4 Examinations: System, Concept and Organisation

Various types of evaluation methods are widely used. Courses are not often evaluated only by the final examination. Assignment, laboratory work, home work, seminar etc. may contribute to the final grade of a course. The final examination also can be substituted for written intermediary tests in some courses. Examinations are typically written including essays, problem-solving or case-based questions and calculation problems. Evaluation methods used in Energy Technology and the impact to the final grade is presented in Appendix EN9. The evaluation method used in the course is described in the study guide.

Examinations are arranged according to the curriculum. Examinations outside the schedule can also be arranged.

Courses are usually evaluated on the scale excellent (5), very good (4), good (3), very satisfactory (2), satisfactory (1) and failed (0). Sometimes a pass–fail grading is used. The maximum score for each course is 100 points, and 50 points is required to pass the course.

Four examinations are arranged in each course, of which a student can participate in two examinations. The first two examinations are scheduled for the examination period following the teaching period during which the course is taught. Student can choose either. If a student does not pass the examination after taking it twice, he/she may apply for an additional retake. A retake must be applied for in advance of the exam date in university's exam schedule. There are altogether seven examination weeks during the study year. Results of examinations are posted at notice boards.

Grades obtained in courses are listed in the WebOodi data system that students use to enrol to courses and examinations. Students can view their grades and the weighted average of their

studies at any time. Grades included in the degree, and their weighted average, are listed in the report that complements the diploma.

A final thesis is required to complete the Bachelor's degree programmes. The thesis is independent work of student, and its topic and content are discussed with supervisor before starting the work. The examiner is required to assess the thesis. The examiner and supervisor of B.Sc. thesis must have the degree of M.Sc. at least (Appendix C4). The thesis is graded on the scale of 1–5. The Bachelor Seminar of Energy Technology includes a written B.Sc. thesis, seminar presentation before a colloquium consisting of other Bachelor-level students and teaching personnel and a feedback from other Bachelor-level student. All these three parts are evaluated. The directive assessment matrix is in Appendix EN10. The assessment matrix is presented for the students in the first lecture.

M.Sc. thesis is required to complete the Master's degree programmes. The thesis is evaluated by two examiners and one of them has to be a professor. The other examiner has to have at least M.Sc. degree. The supervisor of M.Sc. thesis must have at least the degree of M.Sc. The thesis is graded on the scale of 1–5. The main issues evaluated in the M.Sc. thesis are the form, definition of the goal, the implementation of the thesis and possible scientific results. The detailed evaluation criteria and the evaluation form are presented in Appendix C6.

At the Bachelor's and Master's levels, a 'maturity test' is used to assess whether the student's achievements are actually his/her own. The topic of the test is determined by the professor responsible for the thesis, and it relates closely to the topic of the student's thesis. The test is evaluated by the professor responsible for the thesis. At the Bachelor's level, a language teacher also evaluates the test to assess the student's language proficiency.

Practical training is included both in the Bachelor's and Master's degree. The student applies for the inclusion of the practical training into the degree, using an application form to which the work certificates are attached to. The application form and the work certificates are to be delivered to the reviewer of the applications to be approved.

5. Resources

5.1 Staff involved

Within LUT Energy, there are about 180 persons working full time. The Department of Energy Technology employs about 55 persons. The composition of teaching and research personnel in LUT is based on a four-step system: Doctoral Student, Post Doctoral Researcher, Associate Professor and Professor, Table 5. This four-step system supports structured and consistent education and development activities. The employment contracts of the personnel range from 1 year contracts (doctoral student) to permanent positions (associate professors, professors). The number of total academic staff accounts 55 including also the researches with no teaching responsibility. The CV of each staff member participating in teaching is enclosed in the staff handbook (Appendix EN11).

Table 5. Staff Contributing to the Degree Programme (2011)

Position type	
Professors[1]	6
Associate Professor[1]	5
Post-doctoral researchers[1]	10
Doctoral Students[1]	21
Other teaching and research staff[1]	13
Total academic staff	55

[1]Personnel with teaching responsibility

5.2 Staff development

Lappeenranta University of Technology aims to create a good working environment for its staff, and to support their professional development and well-being at work.

The University has a human resources committee through which the university personnel have representation in decision-making concerning the development of the working environment and conditions. The Committee also annually revises the measures for professional development and maintaining professional expertise that determine the focus areas of personnel training at the university. The chair of the Committee is the Vice Rector in charge of education. The names of other members and the Committee memoranda are available on the University intranet.

The University organises training in university pedagogy which aims to strengthen the practical teaching competences of the teaching personnel. The extent of the course package is 25 ECTS credits total. At the moment, 9 staff members of Energy Technology have participated their pedagogical training. In addition, the University organises staff training in foreign languages, utilisation of computer programmes and scientific writing. The professors are also obliged to participate in management training organised by the University (provided by JTO School of Management). The costs of staff training organised by the university are covered by general personnel training appropriations.

Each unit offers its staff members the opportunity to take part in staff training outside the university in order to support their professional development and expertise. Doctoral students participate in the courses organised by the Graduate Schools. In addition, an opportunity to participate in the international exchange programmes for teachers and researchers is offered for the staff. Stipends and funding are provided by e.g. the Lappeenranta Technical University Support Foundation. The university also supports the professional development of its personnel by allowing them to take two lessons (2 x 45 minutes) per week for independent study if the employee's supervisor and head of the unit consider that the studies serve the purposes of the working community.

University staff members conduct annual performance and development discussions with their immediate supervisor. The parties of the discussion examine results obtained, set goals for the near future also concerning the professional development and personnel training needed. Instructions for performance and development discussions are available on the University intranet.

5.3 Institutional environment, financial and physical resources

5.3.1 Institutional environment

Description of the institution

University education is governed by the Universities Act (558/2009) (Appendix C1) and the Government on University Degrees 794/2004 (Appendix C2). The roles and responsibilities of the management of education are defined in the Administrative Regulations of the University (Appendix C8). The educational quantitative objectives are agreed upon annually in the negotiations between the University and the Ministry of Education and Culture. The University applies the Regulations on Education and the Completion of Studies (Appendix C4) approved by the Rector. The Regulations define the basic ways of action concerning the teaching and studying at the University, and the degree programmes provided by the University. The Regulations are published on the University's web pages.

The University Board decides the strategic long-term goals of the university teaching and education, and the degree programmes provided by the University. The Board also decides the number of new entrants accepted to the University's degree programmes.

The University Rector makes the decision on the approval of new entrants to the degree programmes. The Rector also appoints, when necessary, the board of examiners to consider the remedial requests concerning the study attainments.

The University has a Vice Rector responsible for education. In addition, each degree programme has an appointed head. The Vice Rector organises a meeting between the heads of the degree programmes once in every two months to discuss the leading, evaluating and developing principles of the degree programmes. The memos of the meetings are published on the University intranet. The Vice Rector also leads the University's supervisory and development group for teaching appointed by the Rector. The objective of the group is to promote the internal cooperation within the University in developing the teaching customs.

The student representation in the University's administrative bodies is determined by the Universities Act and the Administrative regulations of the University. In accordance with the statutory representation in the administrative bodies, the students also have a representation in the University's supervisory and development group for teaching.

Committees responsible for teaching in the degree programme

The university has three faculties: the Faculty of Technology, the Faculty of Technology Management, and the School of Business. The Department of Energy Technology, as part of the Institute of Energy Technology (LUT Energy), belongs to the Faculty of Technology.

The head of the faculty is the dean, and the highest decision-making body in the faculty is the faculty council. The dean acts as the chair of the faculty council. The dean manages the faculty and is responsible for the results of its instruction, research and societal influence. The faculty council

makes decisions regarding the curricula. A study guide presents the aims and organisation of the education, and the course descriptions and learning outcomes of courses in the degree.

The Faculty of Technology has a development group for teaching appointed by the Dean of the Faculty. The group is responsible for developing the quality of teaching and the contents of the degree programmes within the Faculty. The group has representation from each degree programme provided by the Faculty. The group also has three student representatives that are appointed on the basis of the recommendations of the Students' Union.

The Faculty Council is responsible for supervising the quality of teaching. The Council also decides the study plans and the degree requirements. In addition, the Council makes the proposal to the Rector concerning the entry requirements and the number of new entrants accepted to the degree programmes. The Faculty Council accepts the Doctor of Science theses of the graduate students. The whole curriculum is accepted by the Faculty Council.

The Faculty is responsible for the equipment needed in teaching and research. The Dean of the Faculty is responsible for the resources needed in teaching. The Dean also appoints the heads of the Faculty's degree programmes. In addition, the Dean accepts the Master of Science theses of the students.

The heads of the Faculty's degree programmes are responsible for producing, evaluating and developing the degree programmes. The heads of the degree programmes accept the topics of the theses of Master of Science students. Each degree programme of the Faculty also has an advisory group to support the work of the head of the programme.

The content of the major subject of the degree programme is decided by the professors and the head of degree programme. The major subject is congruent with the focus areas of the research. The professors are also responsible for organising teaching in their remits. They also examine the M.Sc. theses.

Teachers in charge of the study courses are responsible for executing, evaluating and developing their own teaching. The University has published LUT Teacher's Quality Manual to support the teaching activity. The handbook is published as a printed version and in electronic format on the University's intranet.

Main areas of research

The Degree Programme in Energy Technology strongly relies on the research carried out in the Department of Energy Technology. LUT Energy is one of the main research institutions in Finland according to the evaluation carried out by the Academy of Finland in 2006.

The main areas of research of the Department are Fluid dynamics, Nuclear safety and engineering, Modelling of energy systems, Sustainable energy systems and Bioenergy Technology. The research is carried out in laboratories. The laboratories are also responsible for maintaining both the teaching laboratory facilities and the research laboratory facilities.

The laboratory of Fluid Dynamics has launched research in modern turbomachinery and high-speed technology. In this field, the laboratory has designed and built a number of ecological and efficient equipment, such as oil-free compressors for the aeration of wastewater, industrial pressurised air, paper mills and refrigerating machines, and ORCs (Organic Rankine Cycles) for distributed energy management. Specialisation of the laboratory are both radial and axial compressors, both radial and axial turbines, gas turbines, steam turbines, high-speed technology and both hydrodynamic and gas bearings. Several prototypes and test facilities have been built during the research. The laboratory is in charge of teaching in fluid dynamics, pumps and compressors, energy conversion systems, as well as turbomachinery in the Degree Programme of Energy Technology.

Nuclear safety and engineering has been carried out at Lappeenranta University of Technology since the University was founded. At the **Laboratory of Nuclear Engineering**, one of the most important research areas is the thermal hydraulics of nuclear power plants. Research areas are experimental and computational modelling of nuclear power plants, development of safety systems and research on new (GENIV) nuclear power plant. Experimental studies and computer analyses are conducted with the Nuclear Safety Research Unit at LUT. The laboratory is in charge of teaching the nuclear engineering in the Degree Programme of Energy Technology and has a special national role on education and research.

The Laboratory of Modelling of Energy Systems concentrates especially on multiphase flows and the modelling of the sustainable energy technology processes utilising them. The most central challenge in the Finnish energy sector is at the moment the reduction of carbon dioxide emissions in order to prevent the climate change. The most important method to achieve the goals is the new combustion technology, like oxygen enhanced combustion and chemical looping combustion which utilise the circulated fluidised bed technology. The special application area of the Modelling of Energy Systems is the research of the processes based on the fluidised bed technology. The objective is the research and development of industrial and larger scale power and heat production. In teaching, the laboratory is in charge of the modelling of fluid dynamics and heat transfer.

The research **in Laboratory of Sustainable Energy Systems** has concentrated in energy conversion, power plant engineering and renewable energy systems. The aim is to develop effective, energy efficient and ecological systems for energy production and distribution. Research on biofuels use in combined heat and power production, and reducing emissions are currently the key areas of research and education in the laboratory. The research on the conversion of biofuels through thermal treatment aims to convert biomasses to more valued end products, such as torrefied biomass or biocoal. The gas combustion research project studies the high-temperature air combustion (HiTAC) of natural gas without creating nitrogen oxides, and the use of nitrogen and other gases as fuels. The laboratory is in charge of teaching the power plant engineering, energy systems and renewable energy.

In the **Laboratory of Bioenergy Technology** the main objective is to increase the energy and environmental efficiency of biomass production chains, thus aiming for more cost-efficient and lower-emission production and logistics chains for biofuels and improved delivery rates. Cost savings achieved through the optimisation of supply logistics and fuel quality are allocated to the

improvement of the energy economics and competitiveness of power plants and biofuel commodity plants.

Examples of current research projects in the laboratories which are relevant also from the perspective of the degree programmes:

Laboratory of **Fluid Dynamics**

- "Oil-free turbocompressors based on high speed technology" The aim is to develop and build low and high pressure turbocompressors based on high speed technology where the rotational speed is higher than the frequency of the electrical network. Computational models based on CFD (Computational Fluid Dynamics) have been developed for the fluid dynamic design of the turbocompressors as well as for analysing the test results. The research results, the test facility, the computational models, and the computer programmes developed are utilised in teaching.

Laboratory of **Nuclear Engineering**

- "Thermal-hydraulics of innovative nuclear systems (THINS)". EU 7th framework programme (FP7/2007-2013). Participating universities: LUT, DUT, UPISA, Imperial College, TUM, UNIBO, UCL, UNIMORE.
  The aim is to synergized infrastructure for thermal hydraulic research of innovative nuclear systems in Europe, in LUT gas cooling studies.
- New type nuclear reactors, NETNUC. Academy of Finland. Participating universities: LUT, Aalto. The aim is to develop safety, effectivity and sustainability of Generation 4 reactors, in LUT especially PBR and SCWR type studies.
- Development of CFD codes for nuclear safety applications within EU projects NURESIM, NURISP and NURENEXT utilizing in-house experimental data.

Laboratory of **Modelling of Energy Systems**

- "Development of High-Efficiency CFB Technology to Provide Flexible Air/Oxy Operation for a Power Plant with CCS". EU 7th frame work, FP7-ENERGY-2008-TREN-1. Collaborative project: VTT, LUT, Endesa, CIUDEN, Foster Wheeler Energia, EDP, PKE, PRAXAIR, ADEX, UNIZARLITEC, CzUT, FWESA, AICIA, Siemens.
  The aim of the project in LUT is the development of sulfur capture model for flexi burn CFB conditions, update of the CFB3D-model for flexi burn, validation of CFB3D-model by pilot data and field data and modelling of selected cases by CFB3D-model, as well as the development of dynamic boiler model and the validation of dynamic boiler model.

Laboratory of **Thermodynamics**

- Fundamental understanding of arterial diseases by means of computational fluid dynamics (CFD) simulations. Academy of Finland.

Laboratory of **Sustainable Energy Systems**:

- "Pressurized combustion in Bio-CHP plant"
  The aim is to develop a research facility for small scale energy systems in biofuel combustion. With pressurising the combustion biofuels could be used in combined heat and power (CHP) generation. The research facility will be used in research and teaching.

The research results improve the employment and business in the South-Carelian Region in Finland.

- "Modelling of power plant condenser"
  The aim is to generate better tools to predict condenser behaviour also in dynamic situations. The model will be implemented in several other power plant simulation programmes as a subprogramme. The research results are utilised in industry.
- "Pulp and paper energy efficiency"
  The aim is to improve power plant electricity generation and process energy use reduction by utilizing new process steps and improved components. The research results are used in teaching

Laboratory of **Bioenergy Technology**:

- "Supply of small-sized energy wood in the South-Savo Region in Finland"
  The project studied and developed large-scale procurement of small-sized energy wood. The project focused on the value chain of small-sized energy wood from forest management to the final use of energy. The results of the project show potential of small-sized energy wood as a resource for large-scale energy use, as long as the supply chain is continuously improved by increasing effectiveness and quality.

Cooperation within the institution

The Degree Programmes of LUT carry out close cooperation. The B.Sc. and M.Sc. degrees in Energy Technology include general scientific studies, foreign languages and communication studies which are produced by other degree programmes in LUT (Mechanical Engineering, Electrical Engineering, and Language Centre), (Appendix EN1). Internal cooperation within the University is promoted by the supervisory and development group for teaching led by the Vice Rector in charge of education. The Degree Programme in Energy Technology uses the same student administration services as the other two degree programmes of LUT Energy.

Student exchange is arranged by LUT International Services, which supports university's internationalisation by developing and maintaining cooperation relationships and agreements with international universities and networks. LUT has an extensive partner network all around the world. The network of over 150 higher education and research institutions forms an excellent basis for collaboration in mobility of students, teachers and researchers, as well as joint education and research projects. The University's Information Services and Technology Unit and LUT Library offer services for the students and staff in LUT.

All three degree programmes in LUT Energy collaborate closely in the main research areas which are the energy efficiency and energy markets. These also form one of the four strategic focus areas of the University.

External cooperation

The Degree Programme in Energy Technology collaborates with a number of Finnish and international universities and research institutes. In addition, co-operation in teaching and research is made with enterprises and energy companies. The co-operation with companies in teaching includes for example visiting lectures from companies. Enterprises offer topics for final

theses and planning assignments. Examples of M.Sc. thesis topics are included in Appendix EN12. The Department of Energy Technology acts as a Technical Support Organization (TSOG) for the Finnish nuclear safety authority STUK providing the most extensive experimental facilities in Finland. LUT is the main university giving nuclear energy education in Finland. It also coordinates the national basic professional course on nuclear safety (YK) with annually 70 students and 100 lecturers from all main nuclear organizations in Finland.

The collaborative university partners of the Department include for instance Aalto University School of Engineering and Tampere University of Technology in Finland and many international universities (Appendix EN13). Economically the most significant enterprise cooperation partners include energy companies (TVO, Fortum Power and Heat, Vattenfall, Endesa), equipment providers (ABB, Andritz, Alstom, Foster Wheeler, Metso Power, Siemens, Sultzer, Switch) and big energy consumers (UPM-Kymmene, Stora Enso, Metsä-Botnia). In addition, there is a plenty of cooperation with local enterprises, the economical significance of which to the whole department is not so high.

The Laboratories of Energy Technology have received funding to research from the Academy of Finland and the European Commission Framework Programmes; for instance from the EU 6th and 7th Framework Programmes for the research projects carried out in various projects in energy technology and nuclear engineering. The Laboratories of Energy Technology participate in EU 7th frame work e.g. in project ”Development of High-Efficiency CFB Technology to Provide Flexible Air/Oxy Operation for a Power Plant with CCS”. Further, the Laboratories of Energy Technology take part in national research project like SAFIR (Safety of Nuclear Power Plants) and CCS (Carbon Capture and Storage) Programme. A more detailed description on the research projects can be found in the staff handbook (Appendix EN11).

The main channels through which the Department interacts with the international scientific community are the international consortia and networks in the field, such as the Energy Hills Consortium in the energy cluster, the OECD Nuclear Energy Agency (NEA) and the EU Sustainable Nuclear Energy Technology Platform (SNETP), IEA Bioenergy task 40 working group, scientific conferences and publications. LUT has been the place for international conferences organised by various laboratories of Energy Technology. In the following year, the 10th European Turbomachinery Conference will be organised in Lappeenranta by the Laboratory of Fluid Dynamics.

All doctoral students belong to doctoral schools organised by LUT and other universities in Finland. LUT Energy is the coordinator for the national Doctoral Program in Computational Fluid Dynamics (CFD). The Department of Energy Technology participates in other doctoral programs such as the Graduate School for Energy Science and Technology (starting 1.1.2012 in the Doctoral Program in Energy Efficiency and Systems (EES)) and the Doctoral Program of the Nuclear Engineering and Radiation Chemistry (YTERA) In 2011, Academy of Finland has granted two significant research grants to the Laboratory of Fluid Dynamics.

5.3.2 Financial Resources

The achievement of objectives affects the financing granted to the University by the Ministry of Education and Culture. The financing decisions are made on an annual basis. In allocating the

money to the Faculty, the University takes into account the results of the Faculty's operation in previous years and the Faculty's development needs. The goals of the Faculty's actions are agreed upon on a yearly basis in the negotiations between the Faculty and the University.

The annual income of the Department of Energy Technology has been around 7 million Euros, Table 6. About two thirds of this money comes from sources other than the university budget. These sources include the Academy of Finland, the Finnish Funding Agency for Technology and Innovation (TEKES), the European Union, and private companies.

Table 6. Annual income from different sources

	University budget €	Other sources €
2009	1 600 000	4 600 000
2010	2 000 000	5 000 000
2011[1]	1 900 000	5 500 000
2012[1]	1 800 000	5 200 000

[1] Figures for 2011 and 2012 from the budget

Professors, who are normally in charge of the course modules, are mostly paid from public budget funds, Table 7. This guarantees a solid founding and the continuity of the degree programme. Part of the funding for post doctoral researchers comes from external funding. The funding for doctoral students comes chiefly from research projects and from the Graduate School in Energy Science and Technology and the Graduate School of the Computational Fluid Dynamics (CFD).

Basic teaching and teaching materials, information technology expenses, maintenance of the teaching equipment, rents and charges of the study affairs and the university administration are financed wholly from the budget money.

Table 7. Financial resources of the programme.

	Staff fund total €	Other funds €	Investments in major equipment €
2007[1]	3 475 426	1 059 326	43 583
2008[1]	3 634 562	1 195 211	79 500
2009[1]	3 394 420	1 030 835	81 640
2010[1]	3 803 139	2 139 636	19 719
2011[2]	4 097 000	2 656 000	253 000

1 2007–2010 actual, realised figures

2 Figures for 2011 from the budget

5.3.3 Physical Resources

The University has 34 lecture halls, 9 classrooms for language studies, and 14 micro computer classrooms and work premises for group work and thesis writing.

The university library provides services for university students and staff, and for outside customers. In the library area, there is also a study and work place with guidance for students - the Origo. Origo has about 100 posts, several group work premises, and two computer classrooms. The computer classrooms are available for independent studies whenever they are not reserved for teaching purposes. Origo also has a reading room that is open 24/7.

In the University premises, there are two restaurants and two cafes available for students, staff and other people. Eight rooms have been reserved for students' guilds. The University premises also host two chapels, and the two gyms support the students' physical activities. At the University campus, there is also a student health centre. The Student Union House has facilities for hobbies and meetings that are available to all students.

Computer facilities

University offers for personnel Windows computers of a known brand for normal use or a similar computer with more memory and enhanced display adapter for those who use CAD software. Printers and scanners are available to the personnel. The computers for personnel are equipped with special programmes used in research and teaching purposes. Such programmes are Fluid modelling programmes FLUENT and COMSOL multiphysics, mass and energy balance simulator IPSEPro, dynamic simulator APROS for power plants and MATLAB/Simulink environment with in-house modules for dynamic process modelling. In addition, there are several in-house model codes for modelling multiphase fluid flow and energy processes.

Students can use the computers that are in common use in the library area (i.e. in Origo), or in the computer classrooms. Origo's supporting team supervises the students and the supervision is also carried out with centralised electronic means. The University's Information Services and Technology (IS&T) Unit is responsible for the computers and data systems.

The computers are Windows computers of a known brand. The computers in the classrooms used by the students of Energy Technology are equipped with the computer programme FLUENT, IPSEPro and APROS which are used in teaching. There are printers and scanners also available for students.

There are 84 computers located in the library area, and they are available during the library opening hours. 325 computers located in classrooms are available when there are no lessons. There are 14 computing classrooms, of which 3 are equipped for CAD use. One classroom with 21 computers has a Linux setup. In addition there are 9 workshop rooms which have one or two computer each. On passageways there are some computers that can be used only for web browsing.

Centralised services, such as the learning environments can be accessed also outside of the campus. The university offers eduroam WLAN services to enable the use of students' own computers at the campus.

Students enrol on the modules and exams and see their credit points through WebOodi data system. They get the course information, learning material and assignments of the courses through Noppa and participate in the web-based courses on BlackBoard or Moodle learning space.

Library

LUT Library collections consist of approx. 150 000 printed monographs, 68 000 printed journals, 20 000 electronic books, and 12 000 e-journals. There are also documents in microfiche form and audio recordings. The annual procurement of printed monographs is approx. 7 000 and the number of subscribed printed journals is 900 volumes per year. Electronic material is available remotely for LUT staff and students only.

There are over 20 database vendors with more than 190 databases available for the Library customers. Most database hosts allow IP access to their information sources. Students and staff also have remote access to e-journals and electronic books.

There are no restrictions to the number of loans. The customers access the Library catalogue Wilma 600 000 times per year. The Wilma database includes information about both printed and electronic books as well as the storage information of printed journals. Electronic books can be accessed via a link to the Library catalogue.

The Library provides its customers with library and information services both on-site and online. Information literacy education for the entire University is also arranged and given by the Library personnel. The Librarians act as experts in publishing of the LUT series. The Library is an Independent Institute within the University.

The Library is open to LUT staff, students, and general public during terms on workdays: Mon-Thu 8:00–18:00 and Fri 8:00–15:30. In summer and during the holiday season the Library closes at 15:30 on each workday. There are 100 computer workstations available for the customers. The Library also offers six group work rooms.

Laboratory facilities

Below, the laboratory facilities in the Department of Energy Technology are described in brief

Laboratory of **Fluid Dynamics**

Main facilities are the Radial Compressor Test Station, the Laminar Wind Tunnel, the Axial Compressor and the Supersonic Wind Tunnel. The Laminar Wind tunnel is used both for education and research purposes. It is equipped with a multi manometer, a vertical multi pressure probe, NACA air foil with internal pressure piping on both surfaces, and a smoke generator.

Laboratory of **Nuclear Engineering**

The Laboratory of nuclear engineering and its autonomous part, the Nuclear Safety Research Unit at LUT is a leading national contributor for nuclear education and experimental research of nuclear power plant safety. Several integral test facilities (REWET-III, PACTEL, PWR PACTEL) modelling VVER and PWR type nuclear power plants have been designed and constructed by nuclear safety research unit. With separate effects test facilities the Laboratory of Nuclear engineering has studies the applicability of core catcher design for severe accident situations of NPPs as well as the behaviour of the containment of BWR plants in accident situations. Topics for final theses and planning assignments are offered to the students by the Laboratory of Nuclear Engineering and the Nuclear Safety Research Unit.

Laboratory of **Modelling of Energy Systems** and Laboratory of **Thermodynamics**
Fluid modelling programmes FLUENT, COMSOL multiphysics. Mass and energy balance simulator IPSEPro. Dynamic simulator for power plants APROS. MATLAB/Simulink environment with in-house modules for dynamic process modelling. In addition, several in-house model codes for modelling multiphase fluid flow and energy processes.

Laboratory of **Sustainable Energy Systems**
Mass and energy balance simulator IPSEPro. Dynamic simulator for power plants APROS. MATLAB/Simulink environment with in-house modules for dynamic process modelling. In addition, several in-house model codes for modelling pulp mill mass and energy balances. Small BioCHP test rig where biomass combustion and electricity production can and has been tested for industrial partners. Natural gas combustion rig where HiTAC combustion can be studied. Small heating boiler where pellet combustion can be studied.

Laboratory of **Bioenergy Technology**
The laboratory uses a GIS-based calculation model, built in ArcGIS environment. The model is used for evaluating the profitability of different logistic solutions in forest fuel transportation. In addition to economic effects, the model generates also information about fuel consumption and greenhouse gases. This information is used further in life-cycle assessment of biofuel production and supply (GaBi).

Students perform the laboratory works under the supervision of trained personnel. Supervisors can be other advanced students that are employed by the Laboratory. At the start of their first laboratory course, the students complete an orientation that focuses especially on safe working practices in a laboratory environment. Prior to the first laboratory work, the students are required to sign a form stating that they have received guidance on work safety, and that they have familiarised themselves with first aid instructions.

6 Quality Management and Further Development of Degree Programmes

The key aim in the quality management and development at Lappeenranta University of Technology is to incorporate quality management into the normal activity of the university, with the underlying idea of continuous improvement. The quality targets have been derived from the university strategy (Appendix C3). The university's quality management system covers the entire range of education provided by the university (undergraduate education, postgraduate education, continuing education and open university education), research, societal and regional interaction, and support services.

LUT was audited in 2009 by the Finnish Higher Education Evaluation Council FINHEEC (valid until 5 March 2015; abstract of the audit in Appendix C9). The objective of the FINHEEC audit is to ensure that the higher education institution has a quality assurance (QA) system that supports continuous development of activity. The audit also ensures that a higher education institution operates in accordance with its objectives and the activity is internationally reliable.

6.1 Quality assurance and further development

The university's quality management system is described in the university quality manual (Appendix C10) and the subordinate manuals of organisational units (e.g. support services). These quality manuals include also process descriptions and procedures for key processes. The university's quality management documents and other related material are available on the LUT intranet.

The main quality manual depicts the university's quality policies and goals, key resources, the university's management practices, the university's key processes and their quality management, and practices related to the assessment, measurement and development of activities. The main quality manual lays a foundation for describing the entire quality management system of the university and gives both internal and external stakeholders a comprehensive picture of the quality management of the university's different activities. The main quality manual depicts these activities and practices that apply to and obligate the entire university community.

The university has set quality targets, which have been derived from the university strategy. The following quality targets apply to education.

- *Lappeenranta University of Technology is known for the best Finnish university education in technology and business and is internationally considered an attractive partner in cooperation.*

- *Students at the university will obtain high-level academic know-how, including specialist skills of his/her own field and transferable skills needed to utilise the specialist skills.*

- *The university's students and employers of LUT graduates are satisfied with the contents and implementation of the studies. The teaching staff is satisfied with the conditions provided by the university for teaching.*

- *The possibilities for lifelong learning are diverse and flexible and education is produced according to the needs of the target groups.*

The university has also published LUT Teacher's Quality Manual (Appendix C5) in order to guide teachers to good teaching, as well as Quality Guide for Studying and Learning in LUT (Appendix C11) to strengthen the students' role in the quality of education.

One of the vice-rectors is in charge of education at the university. He/she manages the educational affairs and development of education of the university in cooperation with the heads of degree programmes and steering and development committee for teaching.

The vice-rector and the heads of degree programmes have regular meetings, where they evaluate and discuss about procedures concerning education and needs for development. The steering and development committee for teaching, in an advisory capacity, aids the vice-rector in decision making. The committee, headed by the vice-rector, coordinates and promotes the

development of LUT education, and prepares the application procedure for the quality bonus for teaching and prepares the allocation decision for rector.

Quality assurance at Programme

In each degree programme there is an advisory steering committee for the degree programme. It supports the head of the degree programme in producing, assessing and developing the degree programme. The advisory steering committee consists of the head of the degree programme and a professor from each laboratory. The advisory steering committee of the Degree Programme in Energy Technology meets every two - four weeks and handles issues related to the degree programme's economy, research, and teaching, as well as the development of teaching.

Further development of the degree programme

The key areas in terms of developing the quality of education at LUT are the following:

- development projects for teaching,
- LUT's internal quality bonus for education,
- a pay system with incentives for high-standard education and its development,
- pedagogical and other continuing education for the teaching staff,
- support services for teaching, and
- a system for the recognition of teaching qualifications.

LUT is actively involved in a number of different national and international development projects for teaching. The vice-rector in charge of education decides on development projects which LUT engages in and starts to promote.

The university grants quality bonuses for the development of education for a year at a time. The quality bonus is a reward for development measures taken and an incentive for the further development of education and teaching. The quality bonus 25 000 Euros was granted to the Laboratory of Fluid Dynamics in 2009. The steering and development group for education makes the preparations for the application procedure and the decision to grant a quality bonus, and the rector appoints the recipients of the bonus.

Every year the Student Union of LUT nominates the Lecturer of the Year. In 2007 Professor Jaakko Larjola from the Laboratory of Fluid Dynamics and in 2011 Professor Esa Vakkilainen from the Laboratory of Sustainable Energy Systems were selected to be the Lecturer of the Year. In 2008, Professor Jaakko Larjola was given the nomination of Teacher of the year by the Finnish Foundation for Technology Promotion (Tekniikan Edistämissäätiö,TES).

The university annually offers its teaching staff a study module in university pedagogy worth 25 ECTS credits. At the Moment 9 staff members in Energy Technology have participated in pedagogical training. The teaching staff is also offered other training that supports their teaching and its development, such as training in the use of information and communication technology in instruction. The training is coordinated by Personnel Services. See also 5.2.

The pay system provides an incentive for teachers to develop their teaching and pedagogical skills. The job classification of the teaching staff is based on scientific qualifications and their development, the development of teaching skills and the variety of teaching duties, and

responsibility for one's field of science and its development (pay system guidelines on the intranet).

The support services for education allow teachers to focus on actual teaching and study guidance. The support services provide administrative services related to instruction, as well as technological support e.g. in setting up web-based instruction and educational technology. The responsibility for these support services is shared by Student Services and Information Services and Technology, which operate within the context of University Services, and by faculty support services. Blackboard, a web-based learning environment, is in use on nearly all courses of Energy Technology. During 2012, Blackboard will be replaced in the whole university by Moodle. Information Services and Technology will be responsible for the implementation of the new learning environment and training of the personnel.

The recognition of teaching qualifications and the adoption of teaching portfolios in the appointment of teaching personnel support the development of teaching. For teaching positions, the university recruits professionals with not only strong scientific expertise in the field in question, but with pedagogical skills, as well. To this end, applicants for teaching positions must also submit a teaching portfolio or another report on their teaching qualifications. Instructions for compiling a teaching portfolio are available on the intranet. In addition, the appointment of professors requires a trial lecture from the applicant. The faculty in question supplies the applicant with instructions regarding the trial lecture. Instructions are also available from the university registrar's office.

In the degree programme, there are plans to increase the amount of teaching in English and to change the teaching of Energy Economics according to the needs in the next academic year.

6.2 Instruments, methods and data

During their studies, students fill in several questionnaires with which they can give feedback and tell their opinions concerning the studies and conditions in the university. At the beginning of the studies, freshmen are asked to fill in a questionnaire concerning the progress of studies and tutoring of freshmen. A feedback questionnaire to students and peer tutors helps to evaluate whether the start of studies and initial study guidance has been successful. The feedback survey is carried out annually by the Student Affairs Office. The feedback is discussed with the peer tutors and personnel in charge of study guidance. The feedback combined with practical experiences will be used to develop study guidance for new students and tutor training.

The guild of Energy Technology students Armatuuri compiles feedback from each course twice a year. The feedback is published on the guild's web pages. The feedback is discussed with professors and course teachers and improvement suggestions are reviewed.

The Student Union also compiles student feedback regularly every other year. This questionnaire mainly concentrates on the well being of the students, and it often points out some needs for development in education. The results of the questionnaire are communicated to the university personnel.

Monitoring of credits

A study plan is an important tool to evaluate the progress of studies of an individual student. All LUT students prepare a study plan (HOPS) at the beginning of their studies. All individual study plans are evaluated by the study co-ordinator. Plans which are non-standard are confirmed by the head of the degree programme. The degree programmes are designed and composed so that the completion of degrees is guaranteed within the standard periods of study (3 + 2 years). Examples of student study plans for B.Sc. and M.Sc. degree are included in Appendices EN7 and EN8.

The progress of studies, course pass/failure rates and the accumulation of credits are monitored by the Student Affairs Office. Student Affairs Office compiles these reports and sends them for the heads of degree programmes and study co-ordinators. Reports are discussed and evaluated at the meeting between the heads of the degree programmes organised by the Vice Rector. The meeting minutes are available on the university intranet. The follow-up was started with the first year students in 2010. The accumulation of the credits is followed during the first and second year of study. Credits accumulated to the first year students of Energy Technology quite well, 57,2 ECTS credits on average, Table 8.

Table 8. The accumulation of credits of first year B.Sc. students (academic year 2010-2011)

	B.Sc.1
2010	57,2

The average accumulation of credits per academic year has been 48,1 ECTS credits during 2005-2008.

The accumulation of ECTS credits is controlled individually for each course. Credit accumulation is a key method of performance assessment. Statistics on ECTS credits accumulated are compiled annually for each faculty, and the number of completed credits is one of the grounds for resource allocation to departments.

Modules Development

Student feedback for courses is collected for all of the university's courses in accordance with a university-wide procedure. Teachers together with the feedback system administrators are responsible for collecting student feedback. The electronic feedback questionnaire applies the same assessment criteria to all courses. The objects of assessment include the expediency of the course and a general impression of the course.

The following questions deal with the fulfilment of these criteria:

1. The applied working methods were appropriate for the purposes of the course and they supported my learning during the course. Answers on a scale of 1-5 (5 = I agree completely, 1 = I disagree completely).
2. Overall evaluation of the course (scale of 1-5).
3. Open feedback on the course.

The results of the students' feedback (the average of the questions 1 and 2 for study year) are presented in Table 9. An example of the course feedback is included in Appendix EN14.

Table 9. Course feedback in Energy Technology

	2010-2011	2009-2010	2008-2009	2007-2008	2006-2007
Question 1	3,55	3,34	3,44	3,47	3,59
Question 2	3,54	3,51	3,40	3,42	3,63

The feedback system also allows teachers to add questions to the questionnaire, thus collecting feedback for their own purposes. This, combined with the open feedback field in all of the questionnaires, supports the teachers' own professional development. Students are motivated to give feedback by preparing course-specific questions in addition to the general ones.

The feedback for each course is recapitulated by the system administrator every semester with a general reporting form. The reports are forwarded to the heads of degree programme and to the quality manager, who then submits the reports to the vice-rector in charge of education before the performance and development discussions between the university management and faculties. The units' performance target negotiations deal with student feedback, and if the average assessment for a course is very low (e.g. 2.5 or lower), the vice-rector in charge of education shall intervene and discuss about the topic with the faculty concerned. In addition, the pass/fail record of each course is followed and discussed in the meeting between the heads of the degree programmes organised by the Vice Rector.

The students of the Energy Technology degree programme make a summary of the open feedback for each course. A conversation of the feedback between the student and the teachers of the courses and the head of the degree programme is organised twice a year.

Also the university pedagogical studies and the Teacher's Quality Manual provide the teachers with methods to develop their courses (see 5.2).

Evaluation of the success of the degree programme

The university management, faculty management, heads of departments and heads of degree programmes shall ensure that the education provided by the university is efficient and of a high standard. Success of the degree programme is evaluated in many ways, which are described in the following.

Competence of graduates

Skills and knowledge accumulated by students during the entire education process are demonstrated in a final thesis, which is prepared by all Bachelor's and Master's level students. The distribution of the grades of the B.Sc. and M.Sc. theses in Energy Technology is demonstrated in Tables 10 and 11. In 2008-2010, the most common thesis grade has been 4. The students who had started to study in a university before autumn 2005 had a right to continue studies in the Master's degree programmes without a B.Sc. degree and had to graduate not later than in July 2010. This might be the main reason for some low grades in 2009 and 2010.

Table 10. The grades of the B.Sc. thesis in 2008-2010

Grade of the B.Sc. Thesis	1	2	3	4	5
no/2010			5	10	9
no/2009			1	13	3
no/2008			1	4	1

Table 11. The grades of the M.Sc. thesis in 2008-2010

Grade of the M.Sc. Thesis	1	2	3	4	5
no/ 2010	1	2	12	14	8
no/ 2009		2	5	17	3
no/ 2008			7	18	5

The distribution of the final grade (weighted mean) of the graduates in 2010 is presented in Table 12.

Table 12. Final grades of the graduates in 2010

Degree programme	1-1,99	2 – 2,99	3 – 3,99	4 – 5
Bachelor		11	12	1
Master	3	22	11	1
Total				

Quantitative results of a degree programme

Information on the number of graduates (Table 13) and the time in which their degree was completed (Table 14) is compiled into statistics by the LUT Student Services. The employment of graduates a year after graduation to M.Sc. is generated by Statistics Finland (Table 15).

Before 2005, the Finnish system had no Bachelor's degree in universities of technology, and the students completed directly the M.Sc. degree. The first B.Sc. graduated in 2008. The number of graduates from the M.Sc. degree programme has been rather stable during the last five years, except in 2010. The reason for this was that Finland ratified the Council of Europe and UNESCO Convention on the Recognition of Qualifications concerning Higher Education in the European Region (Bologna Process) in 2005. The students who had started to study in a university before autumn 2005 had a right to continue studies in the Master's degree programmes without a B.Sc. degree, but they had to graduate not later than in July 2010. This can be seen also as a higher median time of study in 2010 in Table 14.

Table 13. Graduates per degree programme during 2006-2010

Degree programme	2010	2009	2008	2007	2006
Bachelor	24	17	6	-	-
Master	37	24	28	24	28
Total	61	41	34	24	28

Since the Finnish system is new, there is no long-term reliable data available for the time being to separately evaluate the B.Sc. and M.Sc. degrees (median times of study for B.Sc. and M.Sc. together are listed in Table 14).

Table 14. Duration of the studies - from the beginning of the B.Sc. programme to the graduation from the M.Sc. programme

	2010	2009	2008	2007	2006
Time of study, median	6,96	5,35	5,46	5,82	5,89

A year after the graduation, the students were employed very well in 2007-2009, Table 15. The number of unemployed was 0 in 2007 and 2008.

Table 15. Alumni activity a year after graduation with the M.Sc. degree

	2009	2008	2007
Employed	77 %	92 %	86 %
Unemployed	7 %	0 %	0 %
Employed with part-time studies	13 %	8 %	14 %
Full-time studies	3 %	0 %	0 %

The frequency of student mobility (Table 16) is monitored annually by International Services. Student exchange statistics are compiled on the university intranet (Tietopankki à Opintopalvelut à Kansainväliset palvelut) and published in the university's final accounts documents.

Table 16. Number of foreign students in the degree programmes

		2010	2009	2008	2007
Trainees	**Incoming**	1	1	2	1
	Outgoing	-	-	3	1
Exchange students	**Incoming**	13	17[1]	8[1]	8[1]
	Outgoing	7[2]	4[2]	6[2]	6[2]
Foreign students in the degree programmes		13[3]	-	-	-

1) includes all the LUT Energy incoming students.

2) Most common countries for outgoing exchange students: Germany, Italy, Spain, China, Sweden, Denmark, Australia

3) Master's degree programme in Energy Technology. Major subject: Bioenergy Technology

The Head of the Degree Programme receives data on the individual dropouts and dropout rates, and based on this data, the study coordinator contacts all the dropouts at least once a year. In Table 17 students are divided by degree programmes and years of study.

As described above, in Finland the time to complete studies has been very flexible. The first students who have had a time limit for their studies have enrolled in 2005. This phenomenon can be seen in the tables, as there are very many "N" year students, meaning students who have been studying longer than five years. At this moment, the Bachelor's degree takes theoretically three years, but students who have not completed their studies in six semesters, are called "Bachelor N

students". Only after graduating in the Bachelor's degree the student is counted as a Master's level student. This phenomenon makes the statistics look as if we had very many Bachelor's degree students and not so many Master's degree students. This is not true, since there is no formal rule that a student should graduate in the Bachelor's degree before she/he could start attending Master's degree courses. At the moment, many students graduate in the Bachelor's degree only shortly before graduating in the Master's degree. One reason is also the student financial aid system that used to favour long B.Sc. study times and which was changed only on 1 Aug 2011.

The decreasing number in M.Sc. "N" year students in 2010/2011 in caused by the fact that the student who had started to study before autumn 2005 had to graduate not later than in July 2010.

Table 17. Students divided by the degree programme and year of study/dropout rate

Academic year	1	2	3	B.Sc. N	4	5	M.Sc. N	Total
10/11	43	34	25	100	22	26	14	264
09/10	37	29	27	52	17	21	78	261
08/09	29	29	17	29	40	29	89	262
07/08	22	17	33	8	30	39	91	240
06/07	26	33	30	2	42	31	91	255

Staff-student ratio

The table below presents the teaching staff ratios for the degrees organised by the Institute of Energy Technology (LUT Energy) which hosts the Department of Energy Technology. The teaching staff comprises professors, associate professors, post-doctoral researchers, and doctoral students.

Table 18**.** Students per teacher per year in LUT Energy

	2009	2008	2007	2006	2005
Student-staff ratio	5.3	5.4	5.3	5.1	5.8

Satisfaction in the education

As part of this self-assessment report, student feedback of the degree programmes is in Appendix EN15

Satisfaction in LUT education is surveyed among LUT graduates at the time of graduation, after five and fifteen years in the world of work, and among their employers.

Graduate feedback is collected from all LUT students at the time of their graduation (Table 19) – both Finnish and international students. The feedback is gathered together annually in February-March, and the results are reported on the university level on the intranet (Tietopankki à Laadunhallinta à LTY:n laadunhallintajärjestelmä à Arviointiraportit) and divided and delivered into the degree programmes. Quality manager is responsible for this process together with Student Services.

Table 19. Feedback from graduated Masters of Science in 2006 -2010 (Scale 1-5)

Satisfaction of the graduate on…	2010	2009	2008	2007	2006
Course content	3,6		3,7	3,5	3,4
Professional abilities	3,5	3,6	3,8	3,6	3,7
Transferable skills	3,4	3,3	3,4	3,2	3,1
Knowledge on my own field	3,5	3,6	3,8	3,4	3,6
The ability to apply theoretical knowledge into practice	3,4	3,3	3,6	3,2	3,6
Study guidance and atmosphere in the department	3,8	3,7	3,6	3,5	3,3
Guidance of the Master's Thesis	3,9	3,7	3,5	3,5	3,6

Moreover, feedback is collected annually from LUT graduates with a Master's degree and five years of experience in the world of work (Table 20). The survey is conducted by LUT Career Services as a part of a national career follow-up. After five years of graduation almost all are employed.

Table 20. Alumni activity and satisfaction five years after graduation

	2010	2005
Status in the labour market/Employed, %	97	72
The level of job requirement corresponds well to the academic education , %	74	66
Made use of skills learned during university studies constantly (constantly + to some degree), %	55 (97)	53 (94)
Satisfied with the university degree in relation to career, %	78	

The survey "Satisfaction in LUT education after nine to fifteen years of experience in the world of work" was first carried out in 2011 (Table 21). The table includes the most important skills in the working life, and how well the degree programme has corresponded the needs of the world of work in the opinion of the respondents. In general, 80 % of the respondents are satisfied with the M.Sc. degree. The most significant lack in the degree is the lack of transferable skills.

Table 21. The meaning of some skills in the current work (9-15 years after the graduation) and the competences the degree programme provided (on the scale of 1 to 6).

	Current work	Competences provided by the degree programme
Problem solving skills	5,4	4,1
Ability for analytic, systematic thinking	5,3	4,3
Ability for continuous learning	5,3	4,5
Organising and coordination skills	5,3	3,1
Teamwork skills and further social skills	5,2	3,8
Negotiation skills	5,2	2,8
Communication skills in the mother tongue	5,1	4,0
Presentation skills	5,1	3,3
Data acquisition skills	5,0	4,1

A new procedure concerning employer feedback has been introduced in the beginning of 2010. University follows up on the satisfaction of employers/supervisors in the outcome of thesis projects and in the skills of the students as they transition into the world of work (Table 22). This questionnaire is sent to the employers, and the results are annually reported by the quality manager.

Table 22. Feedback by the commissioner of the Master's Thesis

	2010
Basic knowledge and skills on scale 1-7	5,7
Project management and collaboration competences on scale 1-7	6,1
Communication and presentation skills on scale 1-7	4,8
Overall satisfaction on scale 4-10	8,4

LUT students leaving for student exchange write a report upon their return. The report is then read by International Services and published on the university web site.

The statement of the head of the degree programme about the data on outcomes is enclosed in Appendix EN16.

7. Documentation and Transparency

7.1 Relevant regulations

To receive the Degree of Bachelor of Science from Lappeenranta University of Technology, at least 90 ECTS credits including the Bachelor's thesis, have to be passed in this university (total degree 180 ECTS credits). For the degree of Master of Science in Technology, the minimum is 70 ECTS credits including the Master's thesis (total degree 120 ECTS credits). The degrees and the Finnish universities that can award these degrees are defined in the Universities Act (558/2009) (Appendix C1).

The head of the degree programme makes the decision of the courses included in the degree of an individual student. Courses that are included in the Bachelor's degree cannot be included in the Master's degree.

The detailed regulations of the degree are given in the University Regulations on Education and the Completion of Studies (Appendix C4). National, Master regulations on Master's level studies for universities are given in the Government Decree on University Degrees (National degree regulations 794/2004) (Appendix C2).

7.2 Diploma Supplement

At LUT a diploma supplement is formulated by following the directions of the National Board of Education and always attached to the B.Sc. and M.Sc. degree certificates. The actual degree certificate is in Finnish (Appendix EN17 and EN18). The diploma supplement is in English and meant for international use. Diploma supplement is attached to the degree certificate along with the transcript of records. They include the information about the University, modules included into degree, as well as the grades of the modules and the structure of the degree (Appendix C4, University regulations on Education and the Completion of Studies, § 22). Both major and minor subjects are given an overall grade. The overall grade is the average of all the LUT courses completed by the student in the subject in question, weighted according to the workload of each course (Appendix C12).

APPENDICES:

Appendices C1-C12, EN7-EN14 and EN16-EN18 are not included in this publication

Common:

C1. Universities Act 558/2009
C2. Government Decree on University Degrees 794/2004
C3. LUT Strategy 2013
C4. University Regulations on Education and the Completion of Studies
C5. LUT Teacher's Quality Manual
C6. Evaluation form of Master's Thesis
C7. Final Thesis Introduction
C8. Regulations of Lappeenranta University of Technology
C9. Audit of the Finnish Higher Education Evaluation Council, Abstract 2009, Audit Certificate HEEC
C10. LUT Quality Manual
C11. Quality Guide for Studying and Learning in LUT
C12. The calculation of the Final Grade

Energy Technology:

EN1. Study Guide/Module Handbook (incl. also courses in Programme in Energy Technology offered by other Degree Programmes)
EN2. Learning outcomes of the degree programmes/ASIIN's SSC criteria
EN3. Model Curricular Analysis
EN4. Objectives Matrix Models
EN5. Workload calculations
EN6. Teaching methods and Independent Study
EN7. Example of study plan (B.Sc.)
EN8. Example of study plan (M.Sc.)
EN9. Course evaluation methods
EN10. Evaluation Matrix of B.Sc. Thesis
EN11. Staff Handbook
EN12. M.Sc. thesis topics in 2010 and 2011
EN13. Cooperative international universities
EN14. Course Feedback (example)
EN15. Statement of Students
EN16. Data on outcomes and the statement of the head of the degree programmes
EN17. The certificate including diploma supplement and transcript of records (Bachelor)
EN18. The certificate including diploma supplement and transcript of records (Master)