Assessment report
Limited Programme Assessment

Master Sustainable Energy Technology

Eindhoven University of Technology

Contents of the report

1. Executive summary

In this executive summary, the panel presents the main considerations which led to the assessment of the quality of the Master Sustainable Energy Technology programme of Eindhoven University of Technology, which has been assessed according to the NVAO Assessment Framework.

The panel noted programme management followed up on the recommendations, made by the previous external assessment panel in 2011. Among others, programme management renewed the subject-specific reference framework and took measures to ensure sufficient numbers of qualified lecturers.

The programme's name, Master Sustainable Energy Technology, matches its contents and corresponds to the names of similar programmes.

Programme management of the Master Sustainable Energy Technology programmes of Delft University of Technology, Eindhoven University of Technology and University of Twente work together and have, among others, drafted the joint subject-specific reference framework and aligned the intended learning outcomes. Although it is clear to the panel the current cooperation has some definite advantages, the panel would like to encourage programme management to strengthen this cooperation by sharing best practices among the programmes, by distinguishing the programmes' profiles more clearly and by benefiting from each other's research foci. The panel supports the intentions for extended cooperation as expressed by management of the programmes, such as designing micro-masters, offering online classes, taking part in international consortia and organising symposia.

The panel appreciates the objectives of the Master Sustainable Energy Technology programme of Eindhoven University of Technology to educate students in renewable energy sources, energy efficiency, energy storage, and transport and the societal dimensions of sustainable energy systems. In the subject-specific reference framework for the programme, the sustainable energy technology domain has been adequately described and the programme objectives have been appropriately compared to programmes in this domain of reputed universities in the Netherlands and abroad. Although the domain has been adequately defined, the panel advises continuing the efforts to delineate the *sustainability* concept, as this concept tends to evolve over time.

The programme intended learning outcomes are appropriate, clearly articulated and cover the domain-specific knowledge and skills, multidisciplinary knowledge and skills, research competencies and academic skills to be achieved by students. The intended learning outcomes meet the requirements of the subject-specific reference framework and match the academic master programme criteria. In the intended learning outcomes, the domain of the programme is well-elaborated and the T-shaped engineer profile is adequately expressed. They meet professional field requirements.

The admission requirements and procedures of the programme are adequate, as may be deduced from the entry requirements, the homologation courses and the pre-master programme.

The panel considers the intended learning outcomes to be met in the curriculum. The correspondence of learning outcomes and curriculum components is, however, addressed at a high level of aggregation. The panel recommends to draft these relations in a more detailed way, in order to be able to validate all of the learning outcomes to be present in the curriculum.

The panel is very positive about the curriculum of the programme. The professional practice is strongly embedded in the curriculum. Research knowledge and skills are elaborately taught. The international dimension is very pronounced, foreign students entering the programme and students in the programme having ample chances to spend part of their studies abroad. The domain-specific knowledge and skills and the multidisciplinary aspects of the programme are addressed appropriately. As a point of further improvement, the panel suggests addressing wind energy more prominently.

The panel assesses the educational principles and study methods of the programme to be adequate. The panel suggests to plan and implement on-line and blended learning initiatives.

The panel considers the student success rates to be good. The student-to-staff ratio is adequate. Although the study guidance in the programme is considered by the panel appropriate, the panel advises to organise the mentoring system in a more structured way. In addition, the panel recommends to further strengthen the community of students in the programme. The panel regards the facilities and laboratories used in the programme to be up-to-standard.

The panel is positive about the lecturers in the programme. They are experts in their fields and nearly all of them have PhD's. As the proportion of BKO-certified lecturers is somewhat limited, the panel suggests raising this number.

The programme examination and assessment rules and regulations are appropriate. They comply with the University and the Faculty of Mechanical Engineering assessment policy statements. The responsibilities of the Examination Committee conform to applicable Dutch rules and regulations. The examination methods meet the learning goals of the courses and are satisfactorily diverse.

The examination and assessment procedures are regarded by the panel to be good. The quality of the examinations is assured through peer review procedures and through the reviews by the Assessment Committee, reporting to the Examination Committee. The internship assessments are satisfactory. The quality of the theses is reviewed by both the Assessment Committee and externally. The *Graduation Projects* are assessed elaborately and strictly, to be deduced from the composition of the Graduation Committee and from the thesis assessment forms. The panel welcomes the conscientious monitoring of the research contents of industry-related projects. To further improve the procedures, the panel suggests making the examiners' requirements more strict and to consider either to introduce rubrics scoring forms for the assessments of reports and projects or to extend and detail the current assessment forms.

The panel found the examinations of the courses to be satisfactory. Having reviewed fifteen master theses of graduates of the programme, the panel concludes these to be up-to-standard and to meet the intended learning outcomes of the programme. None of the theses has been assessed by the panel as unsatisfactory. A number of these proved to be good or very good. From the inspection, the panel can confirm the relatively high grades given for the theses.

From the study of the *Graduation Projects*, the panel found some of these to be rather monodisciplinary. The panel recommends programme management to add multidisciplinary elements and socio-economic reflection to these projects, making use of the expertise of the Innovation Sciences group and considering to assess these aspects both in writing and orally.

The panel considers the graduates to be well-prepared for the positions in this domain on the intended academic master level and to meet the demands of industry.

The panel assesses the Master Sustainable Energy Technology programme of Eindhoven University of Technology to be satisfactory and recommends NVAO to grant re-accreditation to this programme.

Rotterdam, 18 September 2017

Prof. dr. ir. K. Debackere
(panel chair)

drs. W. Vercouteren
(panel secretary)

2. Assessment process

Certiked VBI received a request by Eindhoven University of Technology to conduct a limited programme assessment for the re-accreditation of the Master Sustainable Energy Technology programme.

Certiked requested the approval by NVAO of the proposed panel of experts to conduct this assessment. NVAO have given their approval. The panel composition was as follows (for more detailed information please refer to Annex 4 Assessment panel composition):

- Prof. dr. ir. K. Debackere, full professor Technology and Innovation Management, KU Leuven (panel chair);
- Prof. dr. W.C. Sinke, full professor Photovoltaic Energy Conversion, University of Amsterdam, manager Programme Development Solar Energy, the Energy research Centre of the Netherlands (ECN) (panel member);
- Dr. A. van Dommelen, director of education SENSE Research School, Vrije Universiteit Amsterdam (panel member);
- Prof. dr. P.R.J. Simons, emeritus professor Education in Digital Context, Utrecht University, manager Visie op Leren (panel member);
- N.L. Bach Kolling BSc, student Master Educational Science & Technology, University of Twente, student Bachelor Primary Education Teacher, Saxion University of Applied Sciences (student member)

On behalf of Certiked, drs. W. Vercouteren was responsible for the process coordination and for drafting the panel's report. All panel members and the secretary signed a statement of independence and confidentiality.

The panel conducted this assessment on the basis of the standards of the NVAO Assessment Framework of 19 December 2014 (Staatscourant nr. 36791).

The following procedure was adopted. The panel members studied the documents presented beforehand by programme management, including a number of theses (please refer to Annex 2 and 3: Documents reviewed and Theses reviewed). With respect to the selection and study of the theses, the panel proceeded in line with the NVAO Guidelines for the assessment of final projects during external assessments of 18 February 2015.

Before the date of the site visit, the panel chair and the panel secretary met to discuss the assessment procedures. Before the site visit date, all panel members sent in their preliminary findings, based on the information file submitted by programme management, sent in a number of questions to be put to the programme representatives on the day of the site visit and presented their findings about the theses, they had studied. The panel secretary summarised this information.

On 9 July 2017, the panel had a meeting to discuss the preliminary findings concerning the quality of the programme. During this preliminary meeting, the findings of the panel members, including those about the theses were discussed, and a number of questions were added to the list drafted beforehand. On the basis of this input, the panel secretary drew up a final list of questions, which served as a starting point for the discussions with the programme representatives during the site visit.

On 12 July 2017, the panel conducted a site visit at the Eindhoven University of Technology campus. The site visit schedule was in accordance with the schedule drafted beforehand (please refer to Annex 1 Site visit schedule). Programme management communicated the open office hours to the students and staff of the programme. No persons took the opportunity to meet with the panel.

In a closed session at the end of the site visit, the panel considered every one of the findings, weighed the considerations and drew conclusions regarding the quality of the programme. At the end of the site visit, the panel chair presented a broad outline of the findings to programme management.

A draft version of this report was finalised by the secretary, having taken into account the findings and considerations of the panel. The draft report was sent to the panel members, who studied the draft report and made a number of changes. Thereupon, the secretary edited the final report. This report was presented to programme management to be corrected for factual inaccuracies. After having been corrected for these inaccuracies, the report was sent to the University's Board to accompany their request for re-accreditation of this programme.

3. Overview of the programme

3.1 Basic information about the programme

Administrative information about the programme:

Name programme in CROHO: M Sustainable Energy Technology
Orientation, level programme: Academic Master
Grade: MSc
Number of credits: 120 EC
Specialisations: N.A.
Location: Eindhoven
Mode of study: Full-time (language of instruction: English)
Registration in CROHO: 60443

Administrative information about the institution:

Name of institution: Eindhoven University of Technology
Status of institution: Government-funded University
Institution's quality assurance: Approved

Quantitative data about the programme

Percentage of students who completed the programme in three years (n+1)

Cohort	2010	2011	2012
Percentage of students	81 %	90 %	89 %

Lecturers' qualifications

Qualification	MSc	PhD	BKO
Percentage of lecturers	100 %	87 %	33 %

The student-to-staff ratio is 26.7 (figure calculated for Department of Mechanical Engineering as a whole and, therefore, to be interpreted with caution).

Number of contact hours per week for each of the years of the programme

Year of the programme	Year 1	Year 2
Number of contact hours per week	12.0*	**

*Only core courses (figure is, therefore, to be interpreted with caution; core courses constitute 2/3 of all courses in the first year).
**Not known

3.2 Main facts about the institution

The Master Sustainable Energy Technology programme is a programme of the Department of Mechanical Engineering of Eindhoven University of Technology.

According to their website, the mission statement of Eindhoven University of Technology is to be a leading, international, in engineering science and technology specialised research University. The University wants to offer excellent teaching and research and thereby contribute to the advancement of technical sciences and research in the Eindhoven region and in the world as a whole. The education, research and knowledge valorisation activities of the University are meant to contribute to the solution of major societal issues in the areas of energy, health and smart mobility, to foster the development of technological innovation in cooperation with industry and to strengthen the progress in engineering sciences through excellence in key research areas and through innovation in education.

Eindhoven University of Technology comprises nine departments, being the Departments of Biomedical Engineering, Built Environment, Electrical Engineering, Industrial Design, Industrial Engineering & Innovation Sciences, Chemical Engineering & Chemistry, Applied Physics, Mechanical Engineering and Mathematics and Computer Science. These departments offer 11 Bachelor programmes and 22 Master programmes. More than 10,000 students study at Eindhoven University of Technology, nearly 6,000 of them being Bachelor students and over 4,000 of them being Master students. There are more than 1,000 PhD-students.

3.3 Intended learning outcomes

The intended learning outcomes of the programme are as follows.

- The graduates of the programme are qualified to degree level with the domain of science engineering & technology'.
- The graduates of the programme are competent in the relevant domain-specific discipline(s), namely Sustainable Energy Technology, i.e.
  - Have a thorough understanding of at least one sub-area of Sustainable Energy Technology and are able to maintain and expand their expertise in this field.
  - Have the necessary knowledge and skills to evaluate a broad range of energy technologies and energy systems, taking into account technological societal, economic and sustainability aspects.
  - Are able to analyse and understand the role of sustainable energy technologies in a system. Either as part of an electrical system (connection to the grid), as part of a decentralised system (like a building) or the society as a system with opportunities and barriers for the development of sustainable energy technologies.
  - Are able to contribute to discussions about the complex matters related to the introduction of sustainable energy.
- The graduates of the programme are able to conduct research and design independently.
- The graduates of the programme have the ability to include other disciplines in their research, where necessary.
- The graduates of the programme have a scientific approach to complex problems and ideas.
- The graduates of the programme possess intellectual skills that enable them to reflect critically, reason and form opinions.

- The graduates of the programme have the ability to communicate the results of their learning, thinking and decision-making processes at an international level.
- The graduates of the programme are aware of the temporal and social context of science and technology (comprehension and analysis) and can integrate this context in their scientific work.
- In addition to a recognisable domain-specific profile, the graduates of the programme possess a sufficiently broad basis to be able to work in an interdisciplinary and multidisciplinary context. In this context, multidisciplinary means being focused on other relevant disciplines needed to solve the design of research problem in question.
- The graduates of the programme have the ability to seek new potential applications, taking the social context into consideration.

3.4 Outline of the curriculum

In the table below, the programme curriculum has been presented.

Curriculum components	Credits
Homologation courses and/or Free electives	15 EC
Electrical Power Engineering and System Integration	5 EC
Building Performance and Energy System Simulation	5 EC
Sustainable Energy Sources	5 EC
Energy, Economy and Society	5 EC
System Integration Project	10 EC
Specialisation electives	15 EC
First Year	60 EC
Internship	15 EC
Graduation Project	45 EC
Second Year	60 EC
Total credits of the programme	120 EC

4. Overview of assessments

Standard	**Assessment**
Standard 1. Intended learning outcomes	Satisfactory
Standard 2: Teaching-learning environment	Good
Standard 3: Assessment	Good
Standard 4: Achieved learning outcomes	Satisfactory
Programme	Satisfactory

5. Findings, considerations and assessments per standard

5.1 Standard 1: Intended learning outcomes

The intended learning outcomes of the programme have been concretised with regard to contents, level and orientation; they meet international requirements.

Findings
Sustainable energy technology provides the means for sustainable energy systems. Sustainable energy systems may be defined as systems to secure energy supply at affordable cost, reducing environmental impact and geo-political dependency. The importance of sustainable energy systems is widely recognised, as is evident from declarations by the United Nations and the European Union.

In the words of management of this Master Sustainable Energy Technology programme, the main objectives of this programme are to educate students to become academic engineers who possess scientific knowledge about and understanding of the design, behaviour and performance of energy technologies and the integration of these technologies in grids, buildings and in society at large. The programme is not only directed towards the study of renewable energy sources, such as wind energy, solar energy or bioenergy, but also towards the study of energy efficiency, energy storage and transport and the societal dimensions of the introduction of renewable energy systems.

At the time of the previous accreditation procedure, management of the three Master Sustainable Energy Technology programmes of Delft University of Technology, Eindhoven University of Technology and University of Twente studied the chances to organise a joint-degree programme. This plan has been abandoned, mainly because student mobility between the Universities proved to be a major obstacle. Instead, collaboration on specific topics is sought. This collaboration shows in the subject-specific reference framework, drafted by all three programmes together, in the intended learning objectives which are mutually adjusted and in students enrolling at one University being registered at the other Universities as well, allowing them to take electives of the other programmes.

In the subject-specific reference framework for the three Master Sustainable Energy Technology programmes, management of these programmes defined this domain, emphasising the combination of sustainable energy systems and the engineering properties of technologies in this field. In addition, management of the three programmes conducted a benchmark study, comparing the programmes with programmes in the Netherlands and abroad, such as those of ETH Zürich, University of Reading and Utrecht University. From this comparison, these three programmes are shown to distinguish themselves through their emphasis on the technological and engineering aspects of sustainable energy systems.

Programme management drafted the intended learning outcomes (please refer to the complete list in section 3.3 of this report). In these intended learning outcomes, domain-specific knowledge and skills, multidisciplinary knowledge and skills, research capabilities, academic skills and societal and ethical awareness are addressed.

Programme management has shown by means of a table the intended learning outcomes to comply with the Meijers criteria, being the Dutch Universities of Technology standard for the master level of the learning outcomes.

Considerations
The panel discussed with programme management the cooperation with the programmes of the other Dutch Universities of Technology. It has become clear to the panel the current cooperation has some definite advantages. The panel would like to encourage to strengthen this cooperation by sharing best practices among the programmes, by distinguishing the programmes' profiles more clearly and by benefiting from each other's research foci. The panel supports the intentions for extended cooperation as expressed by management of the programmes, such as designing micro-masters, offering online classes, taking part in international consortia and organising symposia.

The panel approves of the objectives of the programme. The panel appreciates the programme to educate students in renewable energy sources, energy efficiency, energy storage and transport and the societal dimensions of sustainable energy systems.

The panel welcomes the subject-specific reference framework, that has been drafted by management of the three programmes. In this framework, the sustainable energy technology domain has been adequately described and the programme objectives have been appropriately compared to programmes in this domain of reputed universities in the Netherlands and abroad. Although the domain has been adequately defined, the panel advises continuing the efforts to delineate the *sustainability* concept, as this concept tends to evolve over time.

The panel regards the intended learning outcomes of the programme to be appropriate and to be clearly articulated. They cover the domain-specific knowledge and skills, research competencies and academic skills to be achieved by students. In the learning outcomes, the domain of the programme is well-elaborated and the T-shaped engineer profile is adequately expressed. They meet professional field requirements.

The panel observed the intended learning outcomes to meet the requirements of the subject-specific reference framework. In addition, the panel found them to comply with the Meijers criteria of the Dutch Universities of Technology and, therefore, to meet the requirements of an academic master programme.

Assessment of this standard
These considerations have led the assessment panel to assess standard 1, *Intended learning outcomes*, to be satisfactory.

5.2 Standard 2: Teaching-learning environment

The curriculum, staff and programme-specific services and facilities enable the incoming students to achieve the intended learning outcomes.

Findings
The Master Sustainable Energy Technology programme is a programme of the Department of Mechanical Engineering of Eindhoven University of Technology. As the programme is definitely multidisciplinary, lecturers of no less than six Departments of Eindhoven University of Technology are involved in the programme. The programme is managed by the programme director, assisted by the programme coordinator. Students and lecturers are represented in the Education Committee, which advises the director on quality issues. The Examination Committee for the programme oversees the examinations and assessments of the programme, being responsible for two other programmes as well. The committee is composed of representatives of this programme as well as of representatives of the Departments, which participate in the programme.

The number of students enrolling in the programme remained rather stable in recent years, going from the influx of 52 students in 2010 via the influx of 71 students in 2012 to the influx of 68 students in 2014. The proportion of foreign students is quite substantial, amounting to about 50 % of total inflow. Yearly, about 10 to 15 foreign students enter the programme through the European KIC InnoEnergy SELECT programme, which is the collaboration of a number of Universities in Europe, allowing students to study for a year at either of these Universities, in this way completing their master.

Students with Bachelor Electrical Engineering, Mechanical Engineering, Chemical Engineering, Applied Physics degrees or similar programmes of one of the Universities of Technology in the Netherlands are admitted directly to the programme. As has been indicated, admission implies enrolment in the programmes of the other two Universities as well. Students with bachelor degrees of universities of applied sciences are obliged to take the pre-master programme. Students who are admitted but have deficiencies in one or more domains, are required to take homologation courses (5 EC).

Programme management showed in diagram form the relations of the curriculum components to the intended learning outcomes. From this diagram, it may be deduced all intended learning outcomes are adequately represented in the curriculum.

The curriculum of the programme conforms to the Eindhoven University of Technology-wide Graduation School design requirements. The new curriculum, meeting these requirements, is offered from 2015/2016 onwards. The curriculum is composed of mandatory core courses (30 EC), offering the knowledge and skills required to understand energy supply problems and to design and engineer solutions to these problems. One of the courses is *Energy, Economy and Society*, introducing the socio-economic aspects of sustainable energy systems. In the SELECT curriculum, socio-economic elements and entrepreneurship are even more prominent. The final core course is the *System Integration Project* (10 EC), in which students work on assignments, derived from real life. In this course, students use both technical and socio-economic knowledge and skills, they acquired previously and practice team work, academic writing and project management skills. Having completed these core courses, students select specialisation courses (15 EC), which are meant to prepare them for their *Graduation Project*. Mentors guide them in their choices. In addition, students have the opportunity to choose free electives (15 EC). These allow students to specialise in this domain, to learn about entrepreneurship or to broaden their horizon in the domain. Part of the electives may be homologation courses (maximum 15 EC).

Specialisation courses and elective courses are offered in other programmes as well. At the beginning of the second year, students do an internship (15 EC) which is mandatory. Many students opt for internships abroad. At the end of the curriculum, students do their *Graduation Project* (45 EC). Most of these final projects (80 % to 90 %) are industry-related. Students may do the project at the internship company.

The educational principles of the programme are meant to teach students to acquire the theoretical and practical knowledge and skills to address subjects and problems in this multidisciplinary domain. The study methods adopted in the programme include lectures, tutorials, practical training, assignments and projects. In the *System Integration Project*, the internship and in most *Graduation Projects*, students get in touch with the professional field. On-line lectures or blended learning are only scarcely used in the courses. The number of hours of face-to-face education in the first year amounts to 12.0 hours per week for the core courses (10 EC out of 15 EC per quarter). The figure for the second year has not been precisely calculated.

The success rates of students having completed the programme within three years remained rather stable at 81 % for the cohort of 2010, 90 % for the 2011-cohort and 89 % for the cohort of 2012. These figures are on average more than 10 %-points better than those of the years earlier. One of the factors for this trend, so the panel was informed, is the improved scheduling of the *Graduation Projects.*

The student-to-staff ratio for the Department of Mechanical Engineering is 26.7. Students are guided through the curriculum by their mentors, who are lecturers in the programme and who advise them on the specialisation courses to select in preparation of the *Graduation Project.* Students may switch, if they would choose another theme for this project. Every one of the students has access to a mentor. When students start their thesis work, the mentors' tasks are normally taken over by the thesis supervisor, the supervisor of the *Graduation Project*. In addition, students may turn to the study advisor, if facing study problems. Students expressed being content about the guidance by their mentors but favouring the more strict organisation of the mentoring system. Students regard the diverse student population to be challenging but interesting. The student community is gaining strength.

The lecturers in the programme are active researchers in their fields of expertise. Of the lecturers of the core courses, about 87 % are PhD's and about 33 % obtained the Dutch University Teaching Qualification (BKO). Of all lecturers in the programme, 50 % to 60 % are BKO-certified. On the so-called *Education Days*, lecturers meet and discuss, among others, tailoring the specialisation courses to the requirements of this programme.

Considerations
The panel considers the admission requirements and the admission procedures of the programme to be adequate. The panel is positive about the homologation courses allowing students to remedy their deficiencies. The panel also appreciates the pre-master programme.

Having studied the diagram presented by programme management, the panel considers the intended learning outcomes to be met in the curriculum. The correspondence of learning outcomes and curriculum components is, however, addressed at a high level of aggregation, making it difficult to ascertain the intended learning outcomes to be covered. The panel recommends to draft these relations in a more detailed way, in order to be able to validate all of the learning outcomes to be present in the curriculum.

The panel is very positive about the curriculum of the programme. There are a number of reasons for this. The professional practice is strongly embedded in the curriculum. Research knowledge and skills are elaborately taught, as the students with whom the panel met, confirmed. The international dimension is very pronounced, foreign students entering the programme and students in the programme having ample chances to spend part of their studies abroad. The domain-specific knowledge and skills and the multidisciplinary aspects of the programme are addressed appropriately. As a point for further improvement, the panel suggests addressing the subject matter of *wind energy* more prominently.

The panel assesses the educational principles and the study methods of the programme to be appropriate, to be adjusted to the curriculum contents and to allow students to attain the intended learning outcomes. The panel suggests to plan and implement on-line and blended learning initiatives.

The panel considers the student success rates to be good and to have improved over the last years to favourable figures. The student-to-staff ratio is adequate. The study guidance in the programme is considered by the panel to be appropriate. The panel, however, recommends to organise the mentoring system in a more structured way. The panel also advises to continue and strengthen the community of students in the programme.

The panel is positive about the lecturers in the programme. They are experts in their fields and nearly all of them have PhD's. The panel feels the proportion of lecturers having acquired the BKO-certificate to be somewhat limited. The panel therefore, suggests raising the proportion of BKO-certified lecturers.

Having been offered the opportunity to visit some of the facilities and laboratories used in the programme, the panel regards these to be up-to-standard.

Assessment of this standard
These considerations have led the assessment panel to assess standard 2, *Teaching-learning environment*, to be good.

5.3 Standard 3: Assessment

The programme has an adequate assessment system in place.

Findings
The programme examination and assessment rules and regulations comply with the Eindhoven University of Technology Examination Framework and the Department of Mechanical Engineering Assessment Policy. The Examination Committee for the programme has the responsibilities to monitor the examination rules and regulations, to ensure the quality of the examinations and to guarantee the graduates meeting the intended learning outcomes of the programme.

The examination methods adopted in the courses depend on the nature of the learning goals to be assessed and include, among others, written examinations, theoretical assignments, practical assignments, group and individual reports, discussions and presentations.

Examiners are appointed by the Examination Committee. Examinations drafted by one of the examiners are presented to a fellow examiner for peer review. On behalf of the Examination committee, the Assessment Committee inspects the examinations of the courses as well as the master theses. Their findings are reported to the Examination Committee. In addition, an external review of the theses has been conducted, which showed the grades to be justified. The Examination Committee informed the panel being content about the quality of the examinations and the theses. The internship assignment has to be approved by the internship supervisor, being an examiner. Supervisors grade internships on the basis of the internship report and on the basis of the assessment by the external company supervisor. The Examination Committee considers improving this system further. The *Graduation Project* is assessed by the Graduation Committee, which consists of three examiners, one of whom comes from another department. The Graduation Committee assesses the projects on the basis of the written report and the oral defence, using the thesis assessment form. The assessment form includes relevant criteria. Most of the *Graduation Projects* are industry-related. To ensure the research contents of these projects, measures have been taken. Supervisors review the research aspects of the project proposals, the Examination Committee checks the company supervisors' competencies in this respect, supervisors monitor the research contents in the course of the projects and the research contents are part of the assessments.

Considerations
The panel considers the programme examination and assessment rules and regulations to be appropriate, as these comply with the Eindhoven University of Technology and Faculty of Mechanical Engineering assessment policy statements.

The responsibilities of the Examination Committee are appropriate, meeting the applicable Dutch rules and regulations.

The examination methods meet the courses' learning goals and are satisfactorily diverse.

The panel considers the examination and assessment procedures to be good, these procedures ensuring the validity, reliability and transparency of examinations. The quality of the examinations is assured through peer review procedures and through the reviews by the Assessment Committee. For the panel, the internship assessments are satisfactory. The quality of the theses is reviewed by both the Assessment Committee and externally. The panel appreciates the elaborate and strict procedures for the assessment of the *Graduation Projects*, to be deduced from the composition of the Graduation Committee and from the thesis assessment forms. In addition, the panel welcomes the conscientious monitoring of the research contents of industry-related projects. To further improve the examination and assessment procedures, the panel suggests making the examiners' requirements more strict and to consider either to introduce rubrics scoring forms for the assessments of reports and projects or to extend and detail the current assessment forms.

Assessment of this standard
The considerations have led the assessment panel to assess standard 3, *Assessment*, to be good.

5.4 Standard 4: Achieved learning outcomes

The programme demonstrates that the intended learning outcomes are achieved.

Findings
The average grade for the *Graduation Projects* in the panel selection, which conforms to the overall average grade of the theses, is about 7.8.

Graduates of the programme tend to have good opportunities on the labour market and tend to find suitable positions relatively easily. Virtually all of the graduates are employed within six months after graduation. Graduates find jobs as engineers (36 %), researchers (31 %) or consultants (20 %). The majority of graduates find positions in the electrical power engineering industry or in the built environment. They are employed by consultancies and by industrial companies, both small and large. Graduates, interviewed by programme management indicated feeling generally well-prepared for their positions.

From information provided by programme management, it is evident the graduates of the programme are appreciated by representatives of industry.

Considerations
Having studied the examinations of a number of courses, the panel assessed these examinations to be satisfactory.

The panel reviewed a total of fifteen master theses of graduates of the programme. The panel concludes these theses to be up to standard and to meet the intended learning outcomes of the programme. None of the theses has been assessed by the panel to be unsatisfactory. A number of theses proved to be good or very good. From the inspection, the panel can confirm the relatively high grades which have been given for the theses by the examiners.

From the study of the *Graduation Projects*, the panel found some of these to be rather monodisciplinary. The panel recommends programme management to add multidisciplinary elements and socio-economic reflection to these projects, making use of the expertise of the Innovation Sciences group and considering to assess these aspects both in writing and orally.

The information provided on the graduates' careers leads the panel to consider the graduates well-prepared for the positions in this field on the academic master level. The programme graduates meet the demands of industry. The views expressed by the representatives of industry echo these positive findings.

Assessment of this standard
The considerations have led the assessment panel to assess standard 4, *Achieved learning outcomes*, to be satisfactory.

6. Recommendations

In this report, a number of recommendations have been listed. For the sake of clarity, these have been brought together below. The recommendations are the following.

- To strengthen the cooperation between the Master Sustainable Energy Technology programmes of the three Dutch Universities of Technology by sharing best practices among the programmes, by distinguishing the programmes' profiles more clearly and by benefiting from each other's research foci.
- To extend this cooperation by implementing a number of plans, mentioned by management of the programmes, such as designing micro-masters, offering online classes, taking part in international consortia and organising symposia.
- To continue the efforts to delineate the *sustainability* concept, as this concept tends to evolve over time.
- To draft the relations between the intended learning outcomes and the curriculum components in a more detailed way, in order to be able to validate all of the learning outcomes to be covered.
- To address *wind energy* more prominently in the curriculum.
- To plan and implement on-line and blended learning initiatives.
- To continue the efforts to organise the mentoring system in a more structured way.
- To continue and strengthen the community of students in the programme.
- To raise the proportion of BKO-certified lecturers among the total number of lecturers in the programme.
- To state the requirements for examiners more strictly.
- To consider either to introduce rubrics scoring forms for the assessments of *Graduation Projects* or to elaborate the current assessment forms.
- To add multidisciplinary elements and socio-economic reflection to the *Graduation Projects*, making use of the expertise of the Innovation Sciences group and considering to assess these aspects both in writing and orally.

Annex 1 Site Visit Schedule

The site visit took place at the Eindhoven University of Technology Campus on 12 July 2017. The site visit schedule was as follows.

08.30 h. – 09.00 h.	Arrival and deliberations panel (closed session)
09.00 h. – 09.45 h.	Dean and programme management, including brief presentation prof. dr. L.P.H. de Goey (Dean of Department Mechanical Engineering), dr. ir. C.C.M. Rindt (programme director)
09.45 h. – 11.00 h.	Programme management and core lecturers dr. M. Creatore (lecturer, department Applied Physics, Plasma and Materials Processing), M. Creusen-Erica (study advisor, department Mechanical Engineering), ir. ing. D.A.A. van Noort (programme coordinator, department Mechanical Engineering), prof. dr. ir. G.P.J. Verbong (lecturer, department Industrial Engineering & Innovation Sciences) dr. ir. C.C.M. Rindt (programme director, department Mechanical Engineering, Energy Technology and Fluid Dynamics)
11.15 h. – 12.00 h.	Examination Committee prof. dr. W.M.G. Jochems (Examination Committee chair, Eindhoven School of Education), dr. ir. J.A. van Oijen (Examination Committee member, department Mechanical Engineering), dr. H.A. Romijn (Examination Committee member, Department Innovation Sciences), drs. P.M.M. Verbeek (study advisor, department Mechanical Engineering)
12.00 h. – 13.00 h.	Lunch panel (closed session), open office hours 12.00 h. – 12.30 h.
13.00 h. – 13.30 h.	Tour around facilities
13.30 h. – 14.30 h.	Lecturers and theses' examiners dr. M. Gibescu (lecturer, department Electrical Engineering, Electrical Energy Systems), dr. ir. H.C. de Lange (lecturer, department Mechanical Engineering, Energy Technology and Fluid Dynamics), ir. R.C.G.M. Loonen (lecturer, department Built Environment, Building Physics and Services), dr. ir. A.F. Kirkels (lecturer, department Industrial Engineering & Innovation Sciences, Technology, Innovation and Society)
14.30 h. – 15.30 h.	Students and alumni F. Westhoek (student, Education Committee member), J.M. Esparza Serrano (student), E.M. Gralista (student), ir. R. Fonteijn (alumnus, PhD student), ir. T.L. Huizer (alumnus, PDEng student)
15.30 h. – 17.15 h.	Deliberations panel (closed session)
17.15 h. – 17.45 h.	Main findings presented by panel chair to programme management

Annex 2 Documents reviewed

The panel studied the following documents, presented prior to the site visit:
- Self-evaluation Report Master Sustainable Energy Technology
- 4TU.Federation and 4TU-Sustainable Energy Technology cooperation
- Actions based on 2011 assessment of programme
- Learning outcomes programme in relation to 4TU Meijers Criteria
- Overviews of research groups involved in programme
- Cooperation with industry
- Role of research in programme components
- Overview of lecturers, courses and departments
- Student staff ratio Department of Mechanical Engineering
- Reflection points Programme Committee student delegation

In addition, the panel members were offered additional information on various aspects of the programme.

On the day of the site visit, the programme management presented the following documents:
- Course material (representative selection)
- Examinations and assignments (representative selection)
- Internship reports
- Pre-master programme information
- Selection information
- Educational Day information
- MAP Procedure
- BKO course
- Teaching and examination regulations
- Examination Committee regulations
- Examination Committee annual reports
- Examination Committee minutes
- Programme Committee minutes
- Course evaluations

In addition, the panel members were given access to the programme's electronic learning environment.

Annex 3 Theses reviewed

The theses of the following 15 students have been selected for review by the panel

- 676153
- 926227
- 731720
- 644164
- 867635
- 924819
- 642696
- 774991
- 924771
- 630445
- 731617
- 612895
- 679487
- 927753
- 925309

Annex 4 Assessment panel composition

The assessment panel had the following composition:

- Prof. dr. ir. K. Debackere, full professor Technology and Innovation Management, KU Leuven (panel chair);
- Prof. dr. W.C. Sinke, full professor Photovoltaic Energy Conversion, University of Amsterdam, manager Programme Development Solar Energy, the Energy research Centre of the Netherlands (ECN) (panel member);
- Dr. A. van Dommelen, director of education SENSE Research School, Vrije Universiteit Amsterdam (panel member);
- Prof. dr. P.R.J. Simons, emeritus professor Education in Digital Context, Utrecht University, manager Visie op Leren (panel member);
- N.L. Bach Kolling BSc, student Master Educational Science & Technology, University of Twente, student Bachelor Primary Education Teacher, Saxion University of Applied Sciences (student member)

Prof. dr. ir. K. Debackere (panel chair)
Mr. Debackere is full professor Technology and Innovation Management at KU Leuven. He took his doctorate in Management with an ICM-fellowship from Ghent University. He was a Fulbright-Hays post-doctoral fellow at Massachusetts Institute of Technology. In 1993, 1995, 1997 and 2008, he won Best Research Paper Award from the American Academy of Management (Technology and Innovation Management Division) and the Decision Sciences Institute. In 2006, Mr. Debackere was awarded the Belgian VBO-prize for scientific excellence.

Mr. Sinke is full professor Photovoltaic Energy Conversion at University of Amsterdam and manager Programme Development Solar Energy at the Energy research Centre of the Netherlands (ECN). He took his doctorate from Utrecht University. Among his current positions, he is board member of the TKI Urban Energy public-private partnership and visiting researcher at AMOLF. For his contributions to the development and promotion of solar energy, Mr. Sinke was appointed Knight in the Order of the Netherlands Lion.

Dr. A. van Dommelen (panel member)
Mr. Van Dommelen is the director of education of the SENSE Research School for the socio-economic and natural sciences of the environment. He studied Philosophy and Science Dynamics at University of Amsterdam and at the New School for Social Research in New York. Having received a research grant from the Netherlands Organisation for Scientific Research, he conducted methodological research on the risk assessment of applied biotechnology. Mr. Van Dommelen's main interests are, among others, in improvement of PhD education and in research integrity.

Prof. dr. P.R.J. Simons (panel member)
Mr. Simons is emeritus professor Education in Digital Context at Utrecht University and general manager of the consultancy Visie op Leren. He took his doctorate from University of Tilburg. Having had positions in research and education at Universities of Amsterdam, Nijmegen and Tilburg, Mr. Simons became full professor at University of Nijmegen and Utrecht University. He was the director of IVLOS Institute for Teacher Education, Education Development and Study Skills. In addition, he was the director of Netherlands School of Educational Management.

N.L. Bach Kolling BSc (student member)
Ms. Bach Kolling is a student in the Master Educational Science and Technology programme of University of Twente as well as being a student in the Bachelor Primary Education Teacher programme of Saxion University of Applied Sciences. Among others, she served as the chair of the study association Dimensie at University of Twente. Ms. Bach Kolling participates as a student member on a regular basis in accreditation panels.