

Assessment report
Limited Programme Assessment

Master Sustainable Energy Technology

University of Twente

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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 University of Twente, 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.

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

The panel is aware of the curriculum changes that will be implemented and that will be effective as of the next academic year. The focus of this assessment, though, is on the current set-up of the programme. The panel, however, has taken into account the proposed curriculum changes, when drafting and outlining the recommendations in this report.

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 plans 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 University of Twente to educate students in renewable energy sources, energy efficiency, energy storage and transport and the societal dimensions of sustainable energy systems. The panel compliments programme management on the strong multidisciplinary profile of the programme, which in the future will be maintained through the objective to educate engineers of the future.

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 panel regards the admission requirements as adequate. The admission procedures are very effective, offering students ample and varied opportunities to remedy their deficiencies, ranging from additional material in courses to pre-master programmes.

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 suggests 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 appreciates the curriculum of the programme. Students are intensively acquainted both with research in this domain and with the professional practice. The curriculum is strongly multidisciplinary, not only across courses but also in the courses themselves. The international dimension is pronounced, foreign students entering the programme and most other students spending part of their studies abroad. The domain-specific knowledge and skills are addressed appropriately. There are some suggestions for further improvements by the panel in this and in the new curriculum. These are to address the subjects *energy system as a whole*, *smart grids* and *energy policy* more prominently, to remove repetitions in the courses, to monitor the feasibility of the *Thesis Project* going from 45 EC to 30 EC and to seek the collaboration with Wageningen University, especially in the bio-related sustainable energy technology domain.

The panel welcomes the educational principles of project-based learning and the study methods. The panel suggests to plan and implement on-line and blended learning initiatives.

As the student success rates are somewhat disappointing, the panel supports the intentions of programme management to implement the new curriculum and thereby to improve this figure. The student-to-staff ratio is adequate. The study guidance in the programme is intensive and well-organised. The panel welcomes the lecturers' accessibility and assistance to students and hopes programme management may continue this. The panel advises to continue and strengthen the community of students in the programme. The facilities and laboratories used in the programme are up-to-standard.

The panel is positive about the lecturers in the programme. They are experts in their fields, the vast majority of them have PhD's and many of them are BKO-certified. The cooperation among the lecturers is strongly developed.

The panel considers the programme examination and assessment rules and regulations to be appropriate and to be well-elaborated. The responsibilities of the Examination Committee are adequate, conforming to the applicable Dutch rules and regulations. The examination methods meet the learning goals of the courses and are satisfactorily diverse. The panel is positive about the process for assessing individual performances of students in case of group projects. The panel considers the examination and assessment procedures to be good. The examinations' quality is assured through peer review procedures, the use of examination matrices and the analysis of examination results. The internship assessments are adequate. The requirements for examiners are relevant. The panel supports the plans to have the examinations reviewed by the Examination Committee. The procedures for the assessment of the *Master Thesis Projects* are very elaborate and the process by which programme management ensures the research contents and multidisciplinary nature of industry-related projects is very well-organised. The panel favours the plans of programme management to tailor the form to the specifics of this programme and suggests to introduce rubrics scoring forms 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. The panel was content about the multidisciplinary nature of the master theses. 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.

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 University of Twente 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 University of Twente 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);
- E.E.M. Leo BSc, student Master programme Educational Sciences, University of Amsterdam (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 14 July 2017, the panel conducted a site visit at the University of Twente 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: Enschede
 Mode of study: Full-time (language of instruction: English)
 Registration in CROHO: 60443

Administrative information about the institution:

Name of institution: University of Twente
 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	86 %	67 %	53 %

Lecturers' qualifications

Qualification	MSc	PhD	BKO
Percentage of lecturers	100%	80 %	80 %*

*Exemptions included

The student-to-staff ratio is 25 (figure derived from figure for Master Mechanical Engineering programme in which all lecturers lecture as well; figure 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	11.9*	**

*Only core courses (figure is, therefore, to be interpreted with caution).

**Not known

3.2 Main facts about the institution

The Master Embedded Systems programme is a programme of the Faculty of Engineering Technology of University of Twente.

According to the University of Twente website, the mission statement of University of Twente is to be the leading entrepreneurial University, to anticipate future developments and to respond rapidly and effectively to the changing world around us. The University's staff are meant to be experts in their field and to assist in setting the agenda for public debate. University of Twente intends to interact on an ongoing basis with industry, research institutes and government to be able to generate ground-breaking research and world-class innovations. The University wants to produce outstanding graduates who excel by combining expertise from a range of fields, as they design solutions that meet the demands of the future, in the Netherlands and abroad.

More than 9,000 students study at University of Twente, being subdivided in more than 5,000 Bachelor students and about 4,000 Master students.

University of Twente comprises five faculties, being the Faculties Science and Technology, Electrical Engineering, Mathematics and Computer Science, Engineering Technology, Behavioural, Management and Social Sciences and Geo-Information and Earth Observation. These faculties offer 20 Bachelor programmes and 34 Master programmes.

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
Transport Phenomena	5 EC
Energy Systems	3 EC
Technology and Sustainable Development	3 EC
Introduction to Chemical Reactor Engineering	3 EC
Energy from Biomass	4 EC
Electrical Power Engineering and System Integration	4 EC
Energy and Economy	4 EC
Wind Energy	4 EC
Solar Energy	4 EC
Hydrogen Energy	4 EC
System Innovation and Strategic Niche Management	4 EC
Technology and Sustainable Development	3 EC
Electives	15 EC
First Year	60 EC
Internship	15 EC
Thesis 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 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. The programme has an explicit multidisciplinary profile, focusing quite strongly on socio-economic dimensions and business aspects of sustainable 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 plans 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 compliments programme management on the strong multidisciplinary profile of the programme including socio-economic dimensions and business aspects of sustainable energy systems. This profile will in the future be maintained through the objective to educate engineers of the future.

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 Faculty of Engineering Technology of University of Twente. As the programme is definite multidisciplinary, lecturers of no less than four Faculties of University of Twente are involved in the programme. The programme is managed by the programme director, assisted by the programme coordinator, the study counsellor and the international exchange coordinator. Students and lecturers are represented in the Education Committee, which advises the director on quality issues. The Evaluation Committee with only student members, is responsible for evaluating the courses of the programme. The Examination Committee for the programme oversees the examinations and assessments of the programme, being responsible for the Bachelor and Master Mechanical Engineering programmes as well.

The number of students enrolling in the programme stayed rather stable in recent years, going from the influx of 13 students in 2010 via the influx of 19 students in 2012 to the influx of 25 students in 2014. The proportion of foreign students was about 30 % over these years. The programme is also offered as a double degree programme jointly with Bandung Institute of Technology (Indonesia). A number of foreign students take the double degree. Dutch students may spend part of their studies in Bandung.

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 other two Universities' programmes as well. Students admitted with slight deficiencies, are provided extra material in specific courses. If that would not suffice, students may have to take homologation courses. Students reporting more serious deficiencies are obliged to take the pre-master programme. This applies both to students with bachelor degrees of universities of applied sciences or to students with specific academic bachelor degrees. The programme director and the programme coordinator review the applications.

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 is composed of core courses (45 EC). These core courses include the introductory course, giving an overview of the domain (*Technology for Sustainable Development*), core courses offering disciplinary knowledge in the sustainable energy technology field (*Wind Energy, Solar Energy, Hydrogen Technology, Energy from Biomass*), the social sciences course, providing economic and social sciences knowledge with respect to the introduction of sustainable energy technologies in society (*Energy and Economy*) and system integration courses, introducing students to the integration of sustainable energy technology in electrical power systems and in societal systems (*Electrical Power Engineering and System Integration* and *System Innovation and Strategic Niche Management*). All of these courses are mandatory. In addition, the core courses include homologation courses (*Transport Phenomena, Energy Systems* and *Introduction to Chemical Reactor Engineering*). Students who do not need to take homologation courses, may choose additional electives. In the first year, students also select specialisation courses (15 EC), which are meant to prepare them for their *Master Thesis Project*.

Their thesis supervisor guides them in their choices. In the second year, students do the internship or take integration projects for 15 EC to 20 EC. In the last five years, all of the students chose internships. Nearly all of the students spend their internships abroad. At the end of the curriculum, students do their *Master Thesis Project* (45 EC or 40 EC). Most of the projects are industry-related, mostly being conducted at small or medium-sized companies. From the year 2017/2018 onwards, the revised curriculum will be introduced. This curriculum will consist of four themes with mandatory courses in the first year. The second year will be composed of either specialisation courses or the internship (15 EC), the pre-assignment study courses (15 EC) and the master assignment (30 EC). The main objectives of this newly designed curriculum is to improve the study load, as scheduling problems during the first year arising from specialisation courses or electives may be avoided.

The educational principles of the programme are project-based learning, meaning knowledge and skills are mainly acquired by students in learning-by-doing processes. The study methods adopted in the programme include lectures, tutorials, practical training, assignments and projects. The last two methods mentioned typically specify the project-based learning. Through the internships and most of the *Thesis Projects*, students get in touch with the professional field. Excursions to companies are scheduled. 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 is 11.9 hours per week. The figure for the second year has not been precisely calculated.

The success rates of students having completed the programme within three years decreased the last three years from 86 % for the cohort of 2010, 67 % for the 2011-cohort and 53 % for the cohort of 2012. These figures lead to an average student success rate after three years of 62 %. In the three years prior to this period, this average figure was 57 %. Students with whom the panel met, described the programme as moderately challenging, but pointed to scheduling problems and time needed to select internships and thesis subjects.

The student-to-staff ratio is estimated to be about 25. At the start of the programme, all students are invited to attend the introductory week. In this week, they meet the lecturers and are introduced to the core courses, internship procedures and the specialisations. For foreign students, an additional introductory programme is in place, familiarising them with the programme and informing them about practical issues. Students are guided in the first quarter by the programme director and the programme coordinator. From the end of the first quarter onwards, students are guided by their thesis supervisor. This includes selecting the specialisation courses. The programme coordinator monitors the students' study progress and meets students to discuss study planning. If faced by more serious problems, students may turn to the student counsellor. Students informed the panel the student community in the programme is not very strongly developed.

The vast majority of the lecturers in the programme are PhD's (80 %) and are active researchers in their fields of expertise. About 80 % of the lecturers obtained the Dutch University Teaching Qualification (BKO). This figure includes lecturers with exemptions on account of more than 25 years of teaching experience. Lecturers meet very regularly to discuss the programme and the mutual adjustment of courses. Lecturers with whom the panel met, described these meetings to be very productive. Students expressed finding programme management and lecturers to be very easily accessible and very helpful.

Considerations

The panel considers the admission requirements to be adequate, qualified students being admitted. The students are offered ample and varied opportunities to remedy their individual deficiencies, going from additional material in courses to pre-master programmes.

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 plan of programme management to introduce percentages of coverage in this table is a positive step, but may not be sufficient.

The panel is very much appreciative of the curriculum of the programme. Research is embedded in the curriculum. Students are offered ample opportunities to become acquainted with the professional practice. The curriculum is strongly multidisciplinary, not only across courses but also in the courses themselves. The international dimension is pronounced, foreign students entering the programme and most other students spending part of their studies abroad. The domain-specific knowledge and skills are addressed appropriately. To improve the curriculum further, the panel advises to address the subjects *energy system as a whole*, *smart grids* and *energy policy* more prominently. In addition, the panel suggests to remove some of the current repetitions in the courses in the new curriculum. With respect to the new curriculum, the panel advises to monitor the feasibility of the Thesis Project going from 45 EC to 30 EC. In addition, the panel recommends to seek the collaboration with Wageningen University, especially in the bio-related sustainable energy technology domain.

The panel welcomes the educational principles of project-based learning and the study methods and feels they 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 somewhat disappointing and supports the intentions of programme management to implement the revised curriculum, thereby aiming to improve this figure. The student-to-staff ratio is adequate. The study guidance in the programme is considered by the panel to be intensive and well-organised. The panel welcomes the lecturers' accessibility and assistance to students and hopes programme management may continue this way. The panel 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, the majority of them have PhD's and many of them are BKO-certified lecturers. The cooperation among the lecturers is strongly developed.

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

In 2012, programme management drafted the policies about quality assurance of examinations and assessments in which the rules and regulations in this respect have been laid down. This document has been accepted by the Examination Committee of this programme and by the programme director and programme coordinator of this programme as the framework to organise and manage examinations and assessments and assure the quality thereof. These policies are in line with the Faculty of Engineering Technology assessment policy and the University of Twente 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, assignments, reports, articles, presentations and oral examinations. In quite a few courses, the examination methods consist of group assignments. In these cases, oral examinations are added to assess the individual performance of every one of the students.

Examinations drafted by one of the examiners are presented to a fellow examiner for peer review. The examiners include examination matrices, identifying the relations between the course objectives and the contents of the examinations. The results of the examinations are analysed by the examiners. Students are informed about the type of questions they may expect. Examinations are not reviewed by the Examination Committee. The plan is to start this in the study year 2017/2018. Internships are graded by supervisors on the basis of the internship report and on the basis of the assessment by the external company supervisor. The latter only gives an advice and is not the examiner.

The *Master Thesis Projects* are assessed by the Master Assignment Committee, which consists of three examiners, one of whom comes from another research group. In case of industry-related thesis projects, the company supervisor may give an advice on the assessment of the project. The Master Assignment Committee assesses the projects on the basis of the written report and the oral defence by the student, using the thesis assessment form. The assessment form includes relevant criteria. Many of the *Master Thesis Projects* are industry-related. To ensure the research contents and the multidisciplinary nature of these projects, programme management reviews the thesis project proposals on these aspects and broadens or adjusts this proposal to meet the requirements. In future, the Examination Committee will be the reviewer of the proposals. Programme management considers to adapt the assessment form and to tailor this to the specific aspects of this programme.

Considerations

The panel considers the programme examination and assessment rules and regulations to be appropriate and to be well-elaborated. They are in line with the University of Twente and Faculty of Engineering Technology assessment policy statements.

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

The examination methods meet the curriculum components' learning goals and are satisfactorily diverse. The panel is positive about the process for assessing individual performances of students in case of group projects.

The panel considers the examination and assessment procedures to be good, as these procedures ensure the validity, reliability and transparency of examinations. The quality of the examinations is assured through peer review procedures, the usage of examination matrices and the analysis of examination results. The panel regards the internship assessments to be adequate. The requirements for examiners are relevant. The panel supports the plans of programme management to have the examinations reviewed by the Examination Committee. The panel appreciates the elaborate procedures for the assessment of the *Master Thesis Projects*, to be seen in the composition of the Master Assignment Committee and in the thesis assessment forms. The panel supports the plans to tailor the form to the specifics of this programme and suggests to introduce rubrics scoring forms or to extend and detail the current forms. The panel is very positive about the process by which programme management ensures the research contents and multidisciplinary nature of industry-related projects.

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 *Master Thesis Projects* in the panel selection, which conforms to the overall average grade of the theses, is about 7.6.

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. About 59 % of them have a position within one month after graduation. Graduates find jobs as engineers (39 %), consultants (17 %) or researchers (11 %). The majority of graduates find positions in wind energy industry (14 %), electrical power engineering industry (14 %) or built environment (14 %). 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. The panel was content about the multidisciplinary nature of the master theses. 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.

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 subjects *energy system as a whole*, *smart grids* and *energy policy* more prominently in the curriculum.
- To remove some of the current repetitions in the courses in the new curriculum.
- To monitor the feasibility of the *Master Thesis Project* going from 45 EC to 30 EC.
- To seek the collaboration with Wageningen University, especially in the bio-related sustainable energy technology domain in the new curriculum.
- To plan and implement on-line and blended learning initiatives.
- To continue and strengthen the community of students in the programme.
- To consider to introduce rubrics scoring forms or to elaborate the current scoring forms for the assessments of the *Master Thesis Projects*.

Annex 1 Site Visit Schedule

The site visit took place at the University of Twente Campus on 14 July 2017. The site visit schedule was as follows.

08.30 h. – 09.00 h.	Arrival and deliberations panel (closed session)
09.00 h. – 09.40 h.	Dean and programme management, including brief presentation prof. dr. G.P.M.R. Dewulf (Dean Faculty of Engineering Technology), dr. ir. J.B.W. Kok (programme director), prof. dr. ir. T.H. van der Meer (former programme director), dr. ir. C.M. Dohmen-Janssen (director of education, Faculty of Engineering Technology)
09.45 h. – 11.10 h.	Programme management and core lecturers dr. ir. J.B.W. Kok (programme director), prof. dr. ir. T.H. van der Meer (former programme director), dr. G.G.M. Stoffels (programme coordinator), ir. M.J.B. Duyvestijn (quality manager, pre-master coordinator), dr. M.J. Arentsen (lecturer)
11.25 h. – 12.10 h.	Examination Committee prof. dr. ir. G.B.R.E. Römer (Examination Committee chair), dr. ir. G.C. Vreman-De Olde (Examination Committee member), drs. E.M. Gommer (educational and test policy advisor)
12.10 h. – 13.10 h.	Lunch panel (closed session), open office hours 12.10 h. – 12.40 h.
13.10 h. – 13.40 h.	Tour around facilities
13.40 h. – 14.40 h.	Lecturers and theses' examiners dr. M.J. Arentsen (lecturer courses Energy and Economy, System Integration and Strategic Niche Management), ir. A.C. Louwes (lecturer course Energy from Biomass), dr. M.M.J. Dhalle (lecturer course Electrical Power Engineering and System Integration), dr. ir. A. Reinders (lecturer course Solar Energy), prof. dr. ir. C.H. Venner (lecturer course Wind Energy), dr. M Shahi MSc (lecturer Energy Storage)
14.45 h. – 15.40 h.	Students and alumni ing. J.A. Baak (student), ing. W.R. Voorberg (student), ing. R.A.J. Elshof (student), H.A. Groendijk BSc (student), ir. R. Yukanananto (alumnus), ir. F. van Dixhoorn (alumna), ir. A. Hofstede (alumnus), ir. M. Ratering (alumnus)
15.40 h. – 17.10 h.	Deliberations panel (closed session)
17.10 h. – 17.30 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
- Organisational setting programme within Faculty of Engineering Technology
- 4TU Federation and 4TU-Sustainable Energy Technology cooperation
- Educational programmes
- Improvements induced by previous assessment
- Learning outcomes programme in relation to 4TU Meijers Criteria
- Overview of elective courses
- Overview of master theses
- Overview of lecturers, courses and faculties

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)
- Overview courses and examination methods
- Internship reports
- Master theses
- Agreement double degree Bandung Technology Institute
- Assessment plans
- Examinations matrices
- Programme regulations
- Course evaluations
- Quality assurance examinations document

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

- 1632930
- 1345885
- 1473336
- 0120413
- 0125016
- 0199893
- 1530208
- 1744941
- 0152846
- 0200905
- 1206346
- 1475347
- 1571184
- 0198935
- 1613502

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);
- E.E.M. Leo BSc, student Master Educational Sciences, University of Amsterdam (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 the 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.

Prof. dr. W.C. Sinke (panel member)

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

E.E.M. Leo BSc (student member)

Ms. Leo is a student of the Master Educational Sciences programme of University of Amsterdam. She completed the Bachelor programme in Educational Sciences at this University. She was a member of the Educational Committee of her programme and vice-chair of the Student Council of the Faculty of Social and Behavioural Sciences of University of Amsterdam. Ms. Leo participates regularly as a student member in accreditation panels.