

Assessment report  
Limited Programme Assessment

**Master Sustainable Energy Technology**

Delft University of Technology

*Contents of the report*

1. Executive summary .....	2
2. Assessment process .....	5
3. Overview of the programme.....	7
3.1 Basic information about the programme .....	7
3.2 Main facts about the institution .....	8
3.3 Intended learning outcomes.....	9
3.4 Outline of the curriculum .....	10
4. Overview of assessments.....	11
5. Findings, considerations and assessments per standard .....	12
5.1 Standard 1: Intended learning outcomes .....	12
5.2 Standard 2: Teaching-learning environment .....	14
5.3 Standard 3: Assessment.....	17
5.4 Standard 4: Achieved learning outcomes .....	19
6. Recommendations .....	20
Annex 1 Site Visit Schedule.....	21
Annex 2 Documents reviewed .....	22
Annex 3 Theses reviewed.....	23
Annex 4 Assessment panel composition .....	24

## 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 Delft 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.

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 Delft 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 and cover the domain-specific 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. The panel advises, however, to establish one definite list of learning outcomes. The panel also recommends to involve professional field representatives more prominently in the programme, for instance in the alignment of the learning outcomes to professional field requirements.

The admission requirements and procedures of the programme are adequate, as may be seen from the entry requirements, the homologation courses and the pre-master programme. In the coming curriculum to be offered from 2017/2018 onwards, programme management will offer adequate alternatives for the homologation courses.

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 covered.

In the panel's view, domain-specific knowledge and skills, research competencies and multidisciplinary dimensions of the domain are appropriately taught in the curriculum. The panel advises to consider giving the internship a more prominent position, in order to allow students to become acquainted with the professional practice. The panel is positive about the curriculum renewal from 2017/2018 onwards, as this may strengthen the system integration and energy transition components in the programme, and may further reinforce the multidisciplinary dimensions. The panel recommends programme management to remain attentive to the implementation of these aspects.

The panel assesses the educational principles and the study methods of the programme to be adjusted to the curriculum contents and to allow students to attain the intended learning outcomes. The panel advises to continue and reinforce the on-going on-line and blended learning initiatives. The student success rates are satisfactory. The panel recommends to monitor these figures, as study durations tend to differ significantly between students. The study guidance in the programme is considered by the panel to be adequate. The student-to-staff ratio is generous. 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 very positive about the lecturers in the programme. They are experts in their fields and nearly all of them have PhD's. The panel is satisfied with the proportion of lecturers having acquired the BKO-certificate and encourages programme management to continue their efforts in this respect.

The panel regards the programme examination and assessment rules and regulations to be adequate. They comply with the Faculty of Electrical Engineering, Mathematics and Computer Science assessment policy statements. The Board of Examiners' responsibilities are appropriate and meet Dutch applicable rules and regulations. The Board fulfils their tasks conscientiously. The examination methods meet the courses' learning goals and are satisfactorily diverse. The panel considers the examinations and assessments procedures to ensure the validity, reliability and transparency of the examinations very adequately. Peer review procedures, the usage of examination matrices and discussions between examiners and the Faculty educational expert add significantly to this. The examinations are assessed appropriately and students have ample opportunities to inspect their work. The assessments of the *System Integration Projects* and the internships are adequate as well. The *Graduation Projects* are well assessed, as can be derived from the elaborate composition of the Thesis Committee and from the rubrics scoring forms. To improve the procedures further, the panel advises to add assessment criteria on system integration and energy transition and not to allow unsatisfactory scores on the criteria initiative and creativity.

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.

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 Delft University of Technology to be satisfactory and recommends NVAO to grant re-accreditation to this programme.

Rotterdam, 2 October 2017

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

drs. W. Vercouteren  
(panel secretary)

## 2. Assessment process

Certiked VBI received a request by Delft 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 10 July 2017, the panel conducted a site visit at the Delft 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: Delft  
 Mode of study: Full-time (language of instruction: English)  
 Registration in CROHO: 60443

*Administrative information about the institution:*

Name of institution: Delft 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	67 %	84 %	66 %

Lecturers' qualifications

Qualification	MSc	PhD	BKO
Percentage of lecturers	100 %	95 %	76 %

The student-to-staff ratio is 13 (approximation).

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	10.5	1.0*

\*Contact hours in graduation courses not included

### **3.2 Main facts about the institution**

The Master Sustainable Energy Technology programme is a programme of the Faculty of Electrical Engineering, Mathematics and Computer Science of Delft University of Technology.

According to the Delft University of Technology website, the University's mission statement is to make a significant contribution towards a sustainable society for the twenty-first century by conducting ground-breaking and world-class scientific and technological research, by training scientists and engineers with genuine commitment to society and by helping to translate knowledge into technological innovations and activity with both economic and social value. Delft University of Technology wants to remain a technology university with a leading global reputation. To do this, the University's aim is to maintain a full range of high-quality disciplines, courses and unique facilities in the engineering sciences.

Delft University of Technology comprises eight faculties, being the Faculties of Aerospace Engineering, Applied Sciences, Architecture and the Built Environment, Civil Engineering and Geosciences, Electrical Engineering, Mathematics and Computer Science, Industrial Design Engineering, Mechanical, Maritime and Materials Engineering and Technology, Policy and Management. These faculties offer 16 Bachelor programmes and 40 Master programmes. About 21,000 students study at Delft University of Technology and about 5,000 staff are employed by the University.



### 3.3 Intended learning outcomes

The intended learning outcomes of the programme are as follows.

- The graduates of the programme have sufficient theoretical and/or practical skills in more than one specialised area of the discipline to be able to carry out research under general supervision.
- The graduates of the programme are able to make connections between and integrate different areas of the discipline.
- The graduates of the programme are able to independently analyse research problems, analyse relevant academic literature, formulate testable hypotheses, set up and carry out research and/or draw up and implement draft plans, and critically reflect on their own research and that of others.
- The graduates of the programme have sufficient understanding of the role of science in society to be able to reflect on this and develop an ethical attitude and practice their profession accordingly.
- The graduates of the programme have the skills to clearly present their own research results both orally and in writing, to communicate with colleagues and to present their research results at conferences or as (part of) a scientific publication.

In addition,

- The graduates of the programme have mastered Sustainable Energy Technology at an advanced academic level. This means mastery of advanced general subjects, such as Solar Energy, Wind Energy, Biomass Energy, Energy Storage, Sustainable Electrical Power Engineering, Energy and Societal topics, and other Sustainable Energy related topics, and the necessary skills in the field of experimental techniques, theoretical analysis, simulation and modelling. This knowledge and these skills should be mastered at a level that is considered at least equal to that of other comparable Master degrees at international, top-quality, educational institutions.
- The graduates of the programme have in-depth knowledge of at least one area within Sustainable Energy Technology, so that international research literature can be understood.
- The graduates of the programme have thorough experience of research in Sustainable Energy Technology and complete awareness of the applicability of research in technological developments.
- The graduates of the programme are capable of understanding a wide variety of different problems and are able to formulate these at an abstract level, whilst being able to see the relation between diverse problems at this abstract level and to contribute creatively to their solution, focusing on practical applications.
- The graduates of the programme are capable of creating innovative technical designs, taking feasibility issues into account.
- The graduates of the programme are capable of working in a (preferably interdisciplinary) team of experts, performing the aforementioned activities and communicating easily in both written and spoken English.
- The graduates of the programme are capable of working independently and taking initiatives where necessary, identifying areas where expertise is lacking and are able to resolve the situation.
- The graduates of the programme are capable of making an English and native language presentation of personal research activities to varied audiences, while being capable of adapting to the background and interest of the audience.
- The graduates of the programme have knowledge of sustainable energy-related developments in society and are capable of developing and defending opinions in this area.

### 3.4 Outline of the curriculum

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

Curriculum components	Credits
Homologation courses (three out of four of the following courses: Transport Phenomena, General Chemistry and Processing Technology, Electrical Power Engineering, Thermodynamics of Renewable Energy Systems)	12 EC
Master Kick-off	0 EC
Renewable Energy	4 EC
Technical Writing	2 EC
Introduction to Wind Energy	4 EC
Practical Wind Energy	1 EC
Photovoltaic Basics	4 EC
Photovoltaic Practical	1 EC
Energy from Biomass	4 EC
Fuel Cell Systems	3 EC
Sustainable Energy Economics	3 EC
System Innovation and Strategic Niche Management	3 EC
Sustainable Hydrogen and Electrical Energy Storage	4 EC
Internship or System Integration Project I or II or free electives	15 EC
First Year	60 EC
Graduation courses	15 EC
Graduation Project	45 EC
Second Year	60 EC
Total credits of the programme	120 EC

#### 4. Overview of assessments

<b>Standard</b>	<b>Assessment</b>
Standard 1. Intended learning outcomes	Satisfactory
Standard 2: Teaching-learning environment	Good
Standard 3: Assessment	Good
Standard 4: Achieved learning outcomes	Satisfactory
<b>Programme</b>	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 the programmes at the three Universities of Technology diversified, putting emphasis on different topics, and because students were not keen to travel between the different locations. 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, research capabilities, a wide range of academic skills as well as 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 this programme. The panel appreciates the programme educating 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. They cover the domain-specific knowledge and skills, research competencies and academic skills to be achieved by students. The panel advises programme management, however, to establish one definite list of learning outcomes instead of the current separated list. The panel also recommends to involve professional field representatives more prominently in the programme, for instance in the alignment of the learning outcomes to professional field requirements. This may be extra important especially as the curriculum will change from the year 2017/2018 onwards (please refer to standard 2).

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 Electrical Engineering, Mathematics and Computer Science of Delft University of Technology. This Faculty has only recently been given this responsibility, the reason being that most students in the programme carry out their thesis project in this Faculty. As the programme is definitely multidisciplinary, lecturers of no less than five Faculties of Delft 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 Board of Studies, which advises the director on quality issues. The Board of Examiners for the programme is a sub-board of the Faculty-wide Board of Examiners and is composed of five members, representing the participating Faculties. This Board oversees the examinations and assessments of the programme.

The number of students enrolling in the programme remained rather stable in recent years, going from the influx of 113 students in 2010 via the influx of 97 students in 2012 to the influx of 83 students in 2014. The proportion of foreign students is substantial, amounting to about 70 % of total inflow.

Students with Bachelor Electrical Engineering, Mechanical Engineering, Chemical Engineering, Applied Physics, and Aerospace Engineering 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 of Technology offering the Master Sustainable Energy Technology programme as well. In case students report deficiencies, they may be required to take the pre-master programme. Students with bachelor degrees of universities of applied sciences are obliged to take this pre-master programme. Students who are admitted but have deficiencies in one or more domains, are required to take homologation courses (total of 12 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 consists of core courses (33 EC) in which knowledge and skills on renewable energy systems, like solar energy, wind energy and bioenergy as well as on energy storage and on the socio-economic aspects of energy systems are taught. The lab courses *Photovoltaic Practical* and *Practicum Wind Energy* provide practical education. As has been indicated before, students take homologation courses (12 EC) to remedy their deficiencies. In addition, students may do either an internship (15 EC), do one or two projects (*System Integration Project I* (6 EC, group project) and/or *System Integration Project II* (9 EC, individual project)) or take electives from a list of designated elective courses for this programme. The electives allow students to specialise in this domain, to learn about entrepreneurship or to broaden their horizon in the domain. About 30 % of the students do an internship. In the second year, students take graduation courses (15 EC), preparing them for the *Graduation Project* (45 EC). Graduation courses should be approved by the Graduation Project supervisor. Most of the courses in the curriculum are specifically designed for this programme, which is an improvement over previous years. From the year 2017/2018 onwards, the curriculum will be redesigned. Students will take core courses (15 EC) and will then select one out of six designated combinations of three profiles (Wind Energy, Solar Energy,

Electrical Sustainable Energy, Energy from Biomass, Energy Storage, Energy and Society). Homologation courses will be replaced by on-line courses prior to the start of the programme or will be incorporated in the profiles. Programme management expects this curriculum to offer a more focus to students without losing the multidisciplinary perspective of the programme.

The educational principles of the programme are meant to acquaint students with both the theoretical and the practical sides of this multidisciplinary domain. The study methods adopted in the programme include lectures, tutorials, practical training, assignments and projects. On-line lectures or blended learning are used in a number of courses. The number of hours of face-to-face education in the first year amounts to 10.5 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 remained rather stable at 67 % for the cohort of 2010, 84 % for the 2011-cohort and 66 % for the cohort of 2012. These figures are on average about 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 curriculum. Students with whom the panel met, expressed experiencing the curriculum to be quite demanding but doable.

The student-to-staff ratio in the programme is favourable at 13. Students are guided by their mentors, who are second year students in the programme. The mentors are trained and supervised by the programme academic counsellor. Students may turn to the academic counsellor, if they face problems in their study. Students informed the panel to be appropriately guided through the curriculum. Students indicated experiencing a community feeling.

Virtually all of the lecturers in the programme are PhD's and are active researchers in their fields of expertise. About 76 % of the lecturers obtained the Dutch University Teaching Qualification (BKO), testifying to their teaching capabilities. A number of part-time lecturers come from the professional field. Programme management informed the panel the cooperation of the Faculties in the programme to be appropriate. Lecturers from various Faculties work together as researchers as well.

### *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. In the prospective curriculum to be offered from 2017/2018 onwards, programme management will include adequate alternatives. The panel 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 appreciates the programme curriculum, as this addresses both domain-specific knowledge and skills satisfactorily. Especially in the second year, research competencies are elaborately taught and examined. In addition, the panel feels the curriculum to meet the multidisciplinary goals of the programme. The panel advises to consider giving the internship a more prominent position, in order to allow students to become acquainted with the professional practice.

The panel is positive about the curriculum renewal from 2017/2018 onwards, as this may strengthen the system integration and energy transition components in the programme, and may further reinforce the multidisciplinary dimensions, adding to the T-shaped engineer profile. The panel advises programme management to remain attentive to the implementation of these aspects.

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 continue and reinforce the on-going on-line and blended learning initiatives.

The panel considers the student success rates to be satisfactory, improvements in the scheduling having been implemented. The panel recommends programme management to monitor these figures, as study durations tend to differ significantly among students. The study guidance in the programme is considered by the panel to be adequate. The student-to-staff ratio is generous. The panel suggests to continue and strengthen the community of students in the programme.

The panel is very positive about the lecturers in the programme. They are experts in their fields and nearly all of them have PhD's. The panel is satisfied with the proportion of lecturers having acquired the BKO-certificate and encourages programme management to continue their efforts in this respect.

Having been offered the opportunity to visit some of the facilities and laboratories used in the programme, the panel considers 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 Faculty of Electrical Engineering, Mathematics and Computer Science assessment policy statements. The Board of Examiners for the programme, being one of the sub-boards of the Faculty-wide Board of Examiners, is responsible 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. As has been indicated, all five Faculties participating in the programme are represented.

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

The examinations drafted by the examiners are inspected by the Faculty educational expert on behalf of the Board of Examiners and are discussed between the examiner and the expert in order to ensure the quality of these examinations. The quality of the examinations and the mandatory examination matrices are discussed. In most cases, examinations are presented to a fellow examiner for peer review. The Board of Examiners appoints the examiners, who in case of the Faculty of Electrical Engineering, Mathematics and Computer Science have to be BKO-certified. In the *System Integration Projects*, students do projects in small groups. Their individual performance is, however, assessed as well. The internship is completed by the internship report, assessed by the company supervisor (2/3 of grade) and the University lecturer (1/3 of grade). The *Graduation Project* is assessed by the Thesis Committee, which consists of three examiners, one of whom comes from another research group. The thesis committee assesses the projects using the thesis assessment form and using the rubrics scoring form to substantiate the grading. The assessment form and the rubrics scoring form address relevant criteria. Only a limited number of students do industry-related projects.

#### *Considerations*

The panel regards the programme examination and assessment rules and regulations to be adequate, as these comply with the Faculty of Electrical Engineering, Mathematics and Computer Science assessment policy statements.

The responsibilities of the Board of Examiners are appropriate and comply with Dutch applicable rules and regulations. The panel appreciates the conscientious manner in which the Board of Examiners fulfil their tasks.

In the panel's view, the examination methods meet the learning goals of the courses 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, usage of examination matrices and discussions between examiners and the Faculty educational expert. The examinations are assessed appropriately. Students have ample opportunities to inspect their work. The assessments of the *System Integration Projects* and the internships are regarded by the panel to be adequate as well. The panel welcomes the elaborate and strict procedures in assessing the *Graduation Projects*, as exemplified by the composition of the Thesis

Committee and by the rubrics scoring forms. To improve these procedures further, the panel recommends to include assessment criteria on the subjects system integration and energy transition and not to allow unsatisfactory scores on the criteria initiative and creativity.

*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 7.7.

Graduates of the programme tend to have good opportunities on the labour market and tend to find suitable positions relatively easily. About 47 % of the graduates are employed within one month after graduation. Graduates find jobs as engineers (42 %), researchers (26 %) or consultants (23 %). They are employed by consultancies and by industrial companies, both small and large. Students with whom the panel met, expressed favouring more guidance by programme management in finding suitable jobs. Graduates, interviewed by programme management indicated appreciating more contact with industry in the programme.

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.

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 establish one definite list of learning outcomes instead of the current separated list.
- To involve professional field representatives more prominently in the programme, for instance in the alignment of the learning outcomes to professional field requirements.
- 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 consider giving the internship a more prominent position, in order to acquaint students with the professional practice.
- To monitor the attention given in the new curriculum to the system integration and energy transition components and to the multidisciplinary dimensions of the programme domain.
- To continue and reinforce the on-going on-line and blended learning initiatives.
- To monitor student success rates, as study durations tend to differ significantly between students.
- To continue and strengthen the community of students in the programme.
- To add assessment criteria on system integration and energy transition and not to allow unsatisfactory scores on the criteria initiative and creativity, to improve the *Graduation Project* assessment processes further.
- To add multidisciplinary elements and socio-economic reflection to the *Graduation Projects*.

## Annex 1 Site Visit Schedule

The site visit took place at the Delft University of Technology Campus on 10 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 dr. ir. J. Schmitz (Dean of Faculty Electrical Engineering, Mathematics and Computer Science), dr. ir. H. Tonino (Faculty director of education), dr. A. Coetzee (manager Education and Student Affairs), dr. R. van Swaaij (programme director), prof. dr. ir. J.L. Kloosterman (former programme director)
09.45 h. – 11.00 h.	Programme management and core lecturers dr. R. van Swaaij (programme director), prof. dr. ir. A. Smets (lecturer), prof. dr. ir. R. van Ommen (chairman Board of Studies), dr. L. Kamp (lecturer), M. Korterink (programme coordinator), L. Boortman (academic counsellor)
11.15 h. – 12.00 h.	Board of Examiners Prof. dr. ir. A. Smets (Board of Examiners chair), prof. dr. D. Roekarts (Board of Examiners member), dr. ir. W. Bierbooms (Board of Examiners member), S. Nijemanting MSc (education advisor), T. Termorshuizen MA (Board of Examiners secretary)
12.00 h. – 13.00 h.	Lunch panel (closed session), open office hours 12.00 h. – 12.30 h.
13.00 h. – 13.45 h.	Tour around facilities
13.45 h. – 14.40 h.	Lecturers and theses' examiners Prof. dr. M. Zeman (lecturer), dr. ir. W. Bierbooms (lecturer), prof. dr. F. Mulder (lecturer), prof. dr. ir. W. de Jong (lecturer), dr. ir. J. Quist (Board of Studies member, lecturer), dr. O. Isabella (lecturer)
14.45 h. – 15.45 h.	Students and alumni I. Diab (student, president Delft Sustainable Energy Association), T. Schoehuijs (student), A. Chamseddine (student), N. Mangat (student, Board of Studies member), J. Quik MSc (alumnus), M. Rodriguez (student, Faculty Student Council member)
15.45 h. – 17.30 h.	Deliberations panel (closed session)
17.30 h. – 18.00 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
- Faculty of Electrical Engineering, Mathematics and Computer Science organisation regarding programme
- 4TU.Federation and 4TU-Sustainable Energy Technology cooperation
- Learning outcomes programme in relation to 4TU Meijers Criteria
- Actions based on 2011 assessment of programme
- Overviews of research groups involved in programme
- Description of curriculum components
- Staff lecturing in the programme
- Teaching and examination regulations
- Board of Examiners regulations

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:

- Literature
- Course material (representative selection)
- Examinations and assignments (representative selection)
- Thesis assessment form and grading scheme
- Board of Studies annual reports
- Board of Examiners annual reports
- Faculty fraud policy

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

- 4251881
- 4255194
- 4053028
- 4416104
- 4412826
- 4250591
- 4328531
- 4257243
- 4420179
- 4422899
- 4316592
- 4320247
- 4331974
- 4258703
- 4311884

## 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.

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.

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.