



MSc Sustainable Energy Technology
University of Twente

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Summary

Standard 1. Intended learning outcomes

The panel concludes that the MSc SET in Twente has appropriate and relevant aims, focusing on studying sustainable energy technologies and the associated socio-economic challenges from multiple perspectives. To further strengthen the profile of the programme, the panel recommends discussing the strengths and opportunities of SET with the relevant stakeholders and focus the profile on these aspects. Possible assets to focus on are the strong emphasis on socio-economic aspects of the energy transition, the small-scale nature of the programme and specific energy research domains that Twente has a strong position in. The panel supports the creation of a SET Industrial Advisory Board to provide the programme with regular external input, for instance on the new profile. The intended learning outcomes of the programme are appropriate and have been formulated on an academic master's level. They are clearly aligned with the expectations of the academic and professional fields through the domain-specific framework of reference. Depending on the results of the discussions on the profile, the ILOs could be adapted to better reflect the new profile.

Standard 2. Teaching-learning environment

The MSc SET has a well-structured, coherent, and multidisciplinary curriculum, with a broad core giving students a solid basis in knowledge and skills relevant to sustainable energy technologies. The specialization phase consisting of electives, an internship and the graduation project provides students with the opportunity to develop their own profile and integrate knowledge and skills. The teaching methods contribute to the realization of the programme objectives, as they allow students to develop a holistic view and connect the various courses. The panel approves of the use of English as the language of instruction, as this aligns with the need to address the challenges related to the energy transition in an international environment. The use of English has been implemented in a satisfactory way, with explicit attention paid to sufficient command of English by students and staff.

The panel supports the initiative to create more room for specialization using wild cards where students can drop certain core courses in exchange for electives. This might help students develop a distinctive profile within SET. An option to further structure this is to create core electives more closely associated to the nature and content of SET. The panel praises the attention the programme pays to guidance of students to compose their individual curriculum. It recommends focusing this guidance on developing the own profile of students in the light of their envisioned future career. The community of staff and students is a strong asset of SET at the UT. The small-scale nature offers room for individual guidance, short feedback lines and frequent contact between staff and students. The curriculum is feasible, with explicit attention being paid to reducing study delay related to pre-knowledge gaps and thesis duration. The panel recommends offering further possibilities for students to self-diagnose possible knowledge gaps for courses, so they have the option to remedy these prior to or in the early stage of a course. The teaching staff is well-qualified for teaching in the programme. Staff members help each other improve their courses through peer feedback. The panel praises the strong, dedicated community of SET teaching staff members, which is not easy to achieve in an interfaculty MSc programme.

Standard 3. Student assessment

The panel concludes that the MSc SET has a solid assessment system that promotes reliable, valid and transparent student assessment. It includes varied assessment methods that fit the programme goals and require students to integrate their knowledge and skills, as well as an assessment plan, guidelines and manuals, and a system of checks and balances by the Board of Examiners. Sufficient attention is paid to the individual obtainment of the ILOs in the case of group projects. Assessment of the graduation projects is

appropriate, with solid procedures for composition of the graduation committees and a clear use of assessment criteria and rubrics. To further improve thesis assessment, the panel recommends paying attention to more extensive written feedback on the assessment forms, and investigating whether a separate assessment criterion for knowledge integration and multidisciplinary can be used.

Standard 4. Achieved learning outcomes

The good quality of the theses, as well as the feedback of alumni, convinced the panel that students of the MSc SET achieve the intended learning outcomes. Further improvements to the theses can be made by working towards a better structuring of the integration of engineering and socio-economic aspects in all theses.

Score table

The panel assesses the programme as follows:

MSc Sustainable Energy Technology

Standard 1: Intended learning outcomes	meets the standard
Standard 2: Teaching-learning environment	meets the standard
Standard 3: Student assessment	meets the standard
Standard 4: Achieved learning outcomes	meets the standard

General conclusion positive

Prof. dr. ir. Koenraad Debackere

Peter Hildering, MSc

Date: 25 September 2023

Introduction

Procedure

Assessment

On 27 June 2023, the master's programme Sustainable Energy Technology of the University of Twente was assessed by an independent peer review panel as part of the cluster assessment Sustainable Energy Technology. The assessment cluster consisted of three programmes, offered by the University of Twente, Eindhoven University of Technology, and Delft University of Technology. The assessment followed the procedure and standards of the NVAO Assessment Framework for the Higher Education Accreditation System of the Netherlands (September 2018).

Quality assurance agency Academion coordinated the assessment upon request of the cluster Sustainable Energy Technology. Peter Hildering acted as coordinator and secretary in the cluster assessment. He has been certified and registered by the NVAO.

Preparation

Academion composed the peer review panel in cooperation with the institutions and considering the expertise and independence of the members, as well as consistency within the cluster. On 15 February 2023, the NVAO approved the composition of the panel. The coordinator instructed the panel chair on his role in the site visit according to the Panel chair profile (NVAO 2016).

The programme composed a site visit schedule in consultation with the coordinator (see appendix 3). The programme selected representative partners for the various interviews. It also determined that the development dialogue would be integrated into the site visit. A separate development report was made based on this dialogue.

The programme provided the coordinator with a list of graduates over the period 2021 – 2022. In consultation with the coordinator, the panel chair selected 15 theses. He took the diversity of final grades and examiners into account. Prior to the site visit, the programme provided the panel with the theses and the accompanying assessment forms. The panel members also received the relevant documentation from the programme, consisting of an extensive set of current documentation pertaining to the four standards of examination that, together with a programme description and SWOT analysis, served as self-evaluation report. This included a comprehensive analysis of the programme's strengths and weaknesses, and a separate and independent student chapter along with the required appendices. Before and during the site visit, the panel studied the additional documents provided by the programmes. An overview of these materials can be found in Appendix 4.

The panel members studied the information and sent their findings to the secretary. The secretary collected the panel's questions and remarks in a document and shared this with the panel members. In a preliminary meeting, the panel discussed the initial findings on the information file and the theses, as well as the division of tasks during the site visit. The panel was also informed on the assessment framework, the working method and the planning of the site visits and reports.

Site visit

During the site visit, the panel interviewed various programme representatives (see appendix 3). The panel also offered students and staff members an opportunity for confidential discussion during a consultation

hour. No consultation was requested. The panel used the final part of the site visit to discuss its findings in an internal meeting. Afterwards, the panel chair publicly presented the preliminary findings.

Report

The secretary wrote a draft report based on the panel's findings and submitted it to an Academion colleague for peer assessment. Subsequently, the secretary sent the report to the panel for feedback. After processing this feedback, the secretary sent the draft report to the programme to have it checked for factual irregularities. The secretary discussed the ensuing comments with the panel chair and changes were implemented accordingly. The panel then finalised the report, and the coordinator sent it to the University of Twente.

Panel

The following panel members were involved in the cluster assessment:

- Prof. dr. ir. Koenraad Debackere, Professor of Innovation, KU Leuven – Chair;
- Prof. dr. Birgitte Bak-Jensen, Professor of Energy Technology, Aalborg University;
- Drs. Jan Steen, Education Consultant, Wageningen University & Research;
- Prof. dr. Wim Sinke, Professor emeritus of Photovoltaic Energy Conversion, University of Amsterdam;
- Jamie Hoetmer, Junior Consultant Energy and Industry, Sia Partners – Student member;
- Cassandra Post, master student Sustainable Energy Technology, University of Twente – Student member;
- Jasper Lagendijk, master student Sustainable Energy Technology, Eindhoven University of Technology – Student member.

The panel assessing the MSc Sustainable Energy Technology at the University of Twente consisted of the following members:

- Prof. dr. ir. Koenraad Debackere, Professor of Innovation, KU Leuven - Chair;
- Prof. dr. Birgitte Bak-Jensen, Professor of Energy Technology, Aalborg University;
- Drs. Jan Steen, Education Consultant, Wageningen University & Research;
- Prof. dr. Wim Sinke, Professor of Photovoltaic Energy Conversion, University of Amsterdam;
- Jamie Hoetmer, Junior Consultant Energy and Industry, Sia Partners – Student member.

Information on the programme

Name of the institution:	University of Twente
Status of the institution:	Publicly funded institution
Result institutional quality assurance assessment:	Positive
Programme name:	Sustainable Energy Technology
CROHO number:	60443
Level:	Master
Orientation:	Academic
Number of credits:	120 EC

Location:	Enschede
Mode(s) of study:	Fulltime
Language of instruction:	English
Submission date NVAO:	1 November 2023

Description of the assessment

Standard 1. Intended learning outcomes

The intended learning outcomes tie in with the level and orientation of the programme; they are geared to the expectations of the professional field, the discipline, and international requirements.

Findings

Profile and aims

The MSc Sustainable Energy Technology (SET) of the University of Twente (UT) is a multidisciplinary programme that aims to educate engineers that contribute to the world's transition from fossil to sustainable energy. A SET engineer should be able to do this from a multidisciplinary point of view, combining insights from different disciplines. During the programme, students acquire the necessary knowledge and skills to evaluate a broad range of energy technologies and energy systems, taking into account technological, societal, economic, behavioural and sustainability aspects. Building on this broad foundation, they should be able to play a role as enabler, leader, and game changer in the transition towards sustainable energy systems. Compared to the other two SET programmes in the Netherlands, the MSc at the UT focuses more on energy sources, conversion technologies and socio-economic aspects of sustainable energy technology. SET is embedded in the Engineering Technology (ET) faculty, with staff involvement of the faculties Science and Technology (TNW), Behavioral and Management Sciences (BMS) and Electrical Engineering, Mathematics and Computer Science (EEMCS).

The panel studied the programme's profile and aims and concludes that these are appropriate and relevant for an MSc in sustainable energy technology. Students learn to study technological challenges related to the energy transition from multiple perspectives, also emphasizing the socio-economic challenges associated with the acceptance of these new technologies, which the panel considers to be a strength of the programme. The panel learnt that the MSc SET is seeking to further develop its profile in the coming years. On the one hand, students and alumni have expressed the desire for developing a more distinctive and recognizable profile, with associated specialization options. On the other hand, SET wants to maintain its broad profile to be able to educate students as generalists with a holistic overview of the field. The panel agrees with the programme management that broadness is one of the strengths of SET and aligns with the requirements of the field. This does not mean that the programme cannot develop a distinctive profile within SET. For instance, the strong emphasis on socio-economic aspects of sustainable energy technologies is an asset that could be further highlighted. Furthermore, the programme could choose a few focus areas that students could further specialize in. Promising topics were further discussed during the thematic session in the site visit. Finally, even though it is not a content-related strength, the panel thinks that the general context and atmosphere within SET form an asset: the small-scale and personal approach of SET in Twente provides a very attractive context for education.

The panel recommends involving stakeholders, including students and staff members, to discuss the distinctive profile and possible unique selling points of the programme, and develop these into a new profile. This process could also benefit from external input from the professional field, for instance through contacts with (regional) industry and alumni. The panel learnt that the programme is planning to initiate an Industrial Advisory Board for regular advice from the professional field on its profile, aims and curriculum. The panel fully supports this.

Intended learning outcomes

Together with the MScs Sustainable Energy Technology at Eindhoven and Delft, the programme composed a domain-specific framework of reference (DSFR), describing the knowledge and skills required of all graduates. In constructing this DSFR, the programmes defined and explained the field of SET, and conducted an international benchmark of comparable MSc programmes. The DSFR has been translated by each of the three institutions into a set of intended learning outcomes (ILOs). The UT formulated 10 ILOs describing the knowledge and skills required of a SET engineer (see appendix 1). The ILOs are formulated along the lines of the Meijer's Criteria, the interpretation of the Dublin Descriptors as often used by engineering programmes.

The panel studied the profile and aims, the DSFR and the intended learning outcomes of the programme. The DSFR describes a comprehensive and broad overview of the field of Sustainable Energy Technology and provides a useful international benchmark. The panel concludes that the programme has composed a clear set of ILOs that clearly reflect the academic master's level and the requirements of the field through the Meijer's criteria and the DSFR. They clearly refer to both the technical and the socio-economic content of SET. The panel noted that the ILOs are quite general in their specification of the knowledge and skills of a SET engineer. The panel recommends making the ILOs more specific on the aspects it chooses to highlight in the new profile of the programme (see above).

Considerations

The panel concludes that the MSc SET in Twente has appropriate and relevant aims, focusing on studying sustainable energy technologies and the associated socio-economic challenges from multiple perspectives. To further strengthen the profile of the programme, the panel recommends discussing the strengths and opportunities of SET with the relevant stakeholders and focus the profile on these aspects. Possible assets to focus on are the strong emphasis on socio-economic aspects of the energy transition, the small-scale nature of the programme and specific energy research domains that Twente has a strong position in. The panel supports the creation of a SET Industrial Advisory Board to provide the programme with regular external input, for instance on the new profile. The intended learning outcomes of the programme are appropriate and have been formulated on an academic master's level. They are clearly aligned with the expectations of the academic and professional fields through the domain-specific framework of reference. Depending on the results of the discussions on the profile, the ILOs could be adapted to better reflect the new profile.

Conclusion

The panel concludes that the programme meets standard 1.

Standard 2. Teaching-learning environment

The curriculum, the teaching-learning environment and the quality of the teaching staff enable the incoming students to achieve the intended learning outcomes.

Findings

Curriculum

The curriculum of the MSc Sustainable Energy Technology consists of 12 compulsory courses (60 EC), electives (15 EC), an internship (15 EC) and a graduation assignment (30 EC). See appendix 2 for an overview.

The *core courses* are all scheduled in the first year and provide students with a broad foundation ranging from technology to entrepreneurship and innovation. The courses are grouped into four themes of three courses each: Energy sources, Technology and sustainability, Socio-economics and Design and system

integration. The themes are scheduled in such a way that students follow courses from different themes alongside each other throughout the first year, providing them with a holistic overview of the challenges and opportunities in sustainable energy. The projects and assignments within the courses stimulate students to integrate knowledge and skills learnt in the other courses.

In the second year, the internship and the graduation project are the focus of the curriculum. In the *internship*, students put the acquired knowledge and skills of the first year into practice in a professional environment. The internship can be carried out in a company or scientific environment outside the UT, depending on the ambitions of the student, and should be focused on a real engineering problem in sustainable energy. It is formally supervised by a SET teaching staff member acquainted with the topic of the internship and performed under daily supervision of an external supervisor in the internship organization. Leading up to the graduation project, students choose 15 EC of *electives* relevant to their intended research topic. The graduation project is an independent research project carried out in a research group under supervision of one of the SET teaching staff members. Students are required to formulate a multidisciplinary project, integrating both the engineering and socio-economic perspective into their research. The supervisor as well as the SET programme management checks each research proposal on this before a student can execute the project.

The panel studied the curriculum and a selection of courses and discussed these with various programme representatives during the site visit. It appreciates the well-structured curriculum, as well as the broad core that gives students a solid basis in sustainable energy technologies, academic and professional skills. In an overview provided to by the programme, the panel noted with appreciation that the intended learning outcomes are used in the design of the curriculum. The overview demonstrated that all ILOs are incorporated in the courses as recommended by the previous accreditation panel. The courses are up-to-date and cover topics relevant for sustainable energy technologies. The multidisciplinary focus, integration of engineering and socio-economic aspects of technology are clearly recognizable in the courses, which the panel appreciates. The themes add coherence to the curriculum, and the many projects and assignments help students integrate knowledge and skills. The internship and graduation project further provide integration. The panel particularly appreciates the requirement that the graduation project has a multidisciplinary scope, and always includes a socio-economic perspective. It noted that the students also appreciated the opportunity to work with real-world challenges.

Specialization and guidance

During the site visit, the panel discussed the broad core curriculum with several groups. The panel learnt from the documentation and interviews that some students would prefer more flexibility for specialization in the curriculum. The 60 EC core provides a very solid basis, but also takes up the entire first year, leaving only 15 EC for electives and profiling next to the internship and graduation project in the second year. As there are many options to choose from for only 15 EC, students find it hard to develop a distinctive profile within this elective space. The programme aims to remedy this by introducing 'wild cards' to the curriculum, where students can drop one or two core courses in the first year in favor of electives. The programme management must approve of the use of wild cards to ensure that the curriculum remains coherent and covers all intended learning outcomes. The panel supports this change and thinks that the extended specialization options might help students develop a distinct profile within SET.

To help students make choices from the broad range of specialization options, the programme invests in counselling in multiple phases of the curriculum. Teachers are the first ones to guide students on the content of their course and are also available when students have questions about internships, thesis topics or specialization courses. When students have to choose their electives in the second year, they can recur to

their prospective thesis supervisor to discuss the required courses to be well-prepared for their thesis. Students who find it difficult to choose the topic of their specialization in the second year have the possibility to contact the programme director or the programme coordinator for a one-on-one consult about their interests and options. Furthermore, the programme organizes two 'homecoming days' per year, where second-year students that have completed their internship or thesis present their results to first-year students, followed by a workshop 'Choosing your graduation topic' by the academic skills teacher.

The panel appreciates the attention the programme pays to help students compose the specialization phase, particularly the option for one-on-one consultation with the intended thesis supervisor or programme management. This is a unique characteristic of a small-scale programme that helps students tailor the curriculum to their own preferences. The panel thinks the programme could further assist students by being more selective in the number of electives offered, as the current list is extensive. It appreciates that students have many options, but also thinks that more SET-specific specialization options will enhance the alignment of the core and specialization parts of the curriculum, as the current electives are often disciplinary and further removed from the SET core and environment. A smaller, more focused set of 'SET electives' could help students find electives that are close to the nature and content of SET. These core electives could for instance consist of courses with a multidisciplinary nature, and a connection of engineering with socio-economic aspects. The programme might even discuss adaptations to electives that it wants to incorporate with the responsible MSc programmes to make them more suitable for SET. This does not mean that students cannot follow other electives anymore if they want to, but a core set might help them compose a more coherent and suitable selection.

In general, the panel thinks that the development of a distinctive profile within the field of SET by students is a balancing act between the guidance provided by the programme, and the own initiative of the student. Students should be stimulated to think about their future career as early as the start of the curriculum, so they can shape their individual curriculum accordingly. The suggestions provided above should be seen in this light: not as a move towards pre-made specializations, but as guidelines to help students orient themselves towards a future career.

Didactics and internationalization

Aligning with the educational vision of the UT, the SET programme has a strong emphasis on student centered learning and collaborative learning. Students are stimulated in several ways to integrate various perspectives and work together and learn from different disciplines and cultural backgrounds. Next to the abovementioned interdisciplinary set-up of the core courses, students often work in multidisciplinary project groups, promoting peer learning. Furthermore, several courses are taught by multidisciplinary teacher teams that offer various perspectives on a topic within the course. Teaching methods include multiple projects and assignments inspired by real-life cases, that require students to integrate multiple perspectives.

The curriculum is offered in English in an international context with students and staff members with different nationalities. The programme believes that the energy transition as a global challenge requires interaction between different cultures, both within the curriculum and in the future career of graduates. Furthermore, to promote the quality of English language education, all lecturers are required to be proficient in English on C1 level minimum. In addition, international students need to demonstrate sufficient command of English as an admission requirement.

The panel is positive about the educational vision and teaching methods of the programme. It praises the diversity of teaching methods and the deliberate choice for didactics that fit the objectives of the course and

the overall programme goals. The projects and assignments allow students to develop a holistic overview of the challenges related to sustainable energy technologies, which also creates connections between the courses. The panel discussed the choice to offer an English-language programme with the programme representatives and agrees with the observations that the ability to operate and communicate in an international environment is crucial for a SET engineer. It therefore supports the decision to use English as the language of instruction. The use of English is also well implemented, with language requirements for both teaching staff and students.

Student support

Community-building is an important aspect of the MSc SET. The programme organizes several social activities to stimulate contact amongst SET students and staff. International students that are new to the programme are invited to a one-on-one introductory talk soon after the start of the academic year to see how the student is coping in the Netherlands as well as in the programme, and to give them the opportunity to bring up any practical or personal issue related to this. Throughout the site visit, the panel noted the close community of staff and students in the SET programme. The panel considers this to be an asset of the programme. The relatively small size (an influx of 30-40 students per year) allows for a small-scale and interactive programme, where students can directly approach teaching staff members and get individual guidance. There are quarterly feedback meetings organized by the programme management where all SET students are invited and can give feedback on any topic relevant to the programme. The panel appreciates these short feedback lines and thinks they further contribute to the quality of the programme.

Feasibility

In order to keep the curriculum feasible for all students, the programme pays specific attention to the heterogeneous background of students. Students can be directly admitted to the programme from a wide range of BSc backgrounds. The Admissions Committee of the programme has a list of national bachelor's degrees that give direct access to the programme. In other situations, the Admissions Committee decides based on the content of the BSc degree whether the student is eligible. In most core courses, the first lecture is spent on catching up on pre-knowledge for the course, aimed at ensuring that all students are aware of the presupposed knowledge, so students can address knowledge gaps if necessary. Throughout the curriculum, a dedicated academic skills teacher further helps students remedy any gaps in academic skills through workshops and individual support. Following the recommendations of the previous panel, the programme management has monitored the feasibility of the graduation project since it was decreased from 45 EC to 30 EC in previous years. The management is generally satisfied with thesis feasibility, but still noted that some students tend to take longer on their graduation project than necessary. It has recently taken additional steps to address this through stricter deadlines and procedures.

Students report the curriculum to be feasible, although not all complete the programme within the designated two years due to personal choices, such as side jobs and extracurricular activities. This is reflected in the success rates. Approximately half of the students complete the programme within the designated two years, and three quarters complete the curriculum after three years. The panel concludes that the curriculum is feasible, and appreciates the actions taken to limit delays related to thesis duration. It advises the programme management to monitor whether these actions have the desired effect and keep working on improving success rates accordingly.

Some students mentioned that they would prefer further options to remedy pre-knowledge gaps prior to the courses, rather than during the first weeks of the course. The panel suggests providing students with options to self-diagnose any knowledge gaps during the first lecture or prior to a course, for instance through self-assignments or tests, with referral to additional study materials.

Teaching staff

The teaching staff is associated with various research groups working on sustainable energy spread over the four faculties contributing to SET. The 24 lecturers that organize the core courses form the group of teaching staff members are the ones most closely associated with the programme. They are active researchers on topics in sustainable energy and teach on topics closely related to their own research. Communication and alignment between teaching staff and programme management is realized by means of the quarterly lecturer meetings to which all teaching staff members of the core courses are invited. All of these lecturers have an University Teaching Qualification (UTQ) or are in the trajectory to obtain this (92%) or have an exemption based on earlier experience (8%).

Based on the documentation and the interviews during the site visit, the panel got a very favorable impression of the SET teaching staff. The staff is committed to the programme and feels ownership of the MSc. The panel praises the programme for this, as community-building among teaching staff associated with different faculties is not easy. Students are positive about the quality of the teaching staff, and (as discussed before) highlight their approachability and the individual guidance they receive. The panel furthermore concludes that there are sufficient staff members to organize the core courses, and there is appropriate attention paid to professionalization in the form of UTQ requirements. It learnt that the teaching staff engages in peer review of exams, where staff members screen each other's exams for validity and transparency. According to the panel, this is a good quality mechanism that also improves the community-building of SET.

Following the discussion on specialization earlier under standard 2, the panel suggests that the programme could try to further expand the SET community by including teachers contributing to future 'core electives'. An additional benefit of a larger network of teaching staff members is that this could create a broader basis for expertise in the various disciplines relevant to the programme. This could mitigate the risk of loss of disciplinary knowledge in the case of changes in teaching staff.

Considerations

The MSc SET has a well-structured, coherent, and multidisciplinary curriculum, with a broad core giving students a solid basis in knowledge and skills relevant to sustainable energy technologies. The specialization phase consisting of electives, an internship and the graduation project provides students with the opportunity to develop their own profile and integrate knowledge and skills. The teaching methods contribute to the realization of the programme objectives, as they allow students to develop a holistic view and connect the various courses. The panel approves of the use of English as the language of instruction, as this aligns with the need to address the challenges related to the energy transition in an international environment. The use of English has been implemented in a satisfactory way, with explicit attention paid to sufficient command of English by students and staff.

The panel supports the initiative to create more room for specialization using wild cards where students can drop certain core courses in exchange for electives. This might help students develop a distinctive profile within SET. An option to further structure this is to create core electives more closely associated to the nature and content of SET. The panel praises the attention the programme pays to guidance of students to compose their individual curriculum. It recommends focusing this guidance on developing the own profile of students in the light of their envisioned future career. The community of staff and students is a strong asset of SET at the UT. The small-scale nature offers room for individual guidance, short feedback lines and frequent contact between staff and students. The curriculum is feasible, with explicit attention being paid to reducing study delay related to pre-knowledge gaps and thesis duration. The panel recommends offering further possibilities for students to self-diagnose possible knowledge gaps for courses, so they have the

option to remedy these prior to or in the early stage of a course. The teaching staff is well-qualified for teaching in the programme. Staff members help each other improve their courses through peer feedback. The panel praises the strong, dedicated community of SET teaching staff members, which is not easy to achieve in an interfaculty MSc programme.

Conclusion

The panel concludes that the programme meets standard 2.

Standard 3. Student assessment

The programme has an adequate system of student assessment in place.

Findings

System of assessment

Assessment in the MSc SET is based on the assessment policy of the Faculty of Engineering Technology. This policy describes the vision on assessment of the faculty, its organization and quality assurance mechanisms. The faculty aims for students to acquire, integrate, and apply knowledge and skills from different areas, with assessment often taking the form of integrative projects that appeal to the problem-solving skills of students. Most courses are assessed through a combination of individual and group assignments, with assessment methods ranging from written exams to research reports, presentations, and papers. This combination prevents students from attaining specific ILOs through free riding. All courses have an assessment plan, in which the different types of assessment in relation to the course objects are detailed. Assessment quality assurance mechanisms include the use of the four-eye principle in designing tests and the use of predetermined assessment criteria. The internship is assessed through an internship report detailing the project results and reflection on personal learning goals by the students, and evaluation on performance by the external internship supervisor. The internal SET internship supervisor uses these three elements to determine the final grade for the internship.

The panel studied the assessment system of the MSc SET, including the assessment plan and some examples of course assessment, and concludes that the programme has a solid and coherent assessment system, with appropriate quality assurance mechanisms. The assessment methods are varied and fit the programme and course objectives, as well as the educational methods. There are various assignments and projects where students need to demonstrate the integration of knowledge and skills and approach a challenge from multiple perspectives. Care is taken that students are individually assessed on all intended learning outcomes, also in the case of group assignments, in order to prevent free riding. The internship is assessed in a satisfactory way, with attention to the personal development goals of the student. The manual for the internship (as well as for the graduation project) provides guidelines and rubrics to ensure consistent assessment and grading.

During the site visit, the panel discussed the perception of students that assessment procedures are not always transparent with several programme representatives. The teaching staff, programme management and Board of Examiners pointed out that all assessment procedures are required to be published before the start of a course, and that this is strictly monitored by the Board of Examiners. The panel suspects that students do not always know or realize that this can be checked beforehand. It advises the programme to spend some time in the first lecture of each course to give a short overview of assessment procedures in the course and pointing students in the right direction for more information.

Board of Examiners

The MSc SET shares a Board of Examiners with the BSc and MSc Mechanical Engineering. The Board consists of five members (one of whom is an external member), of which one is dedicated to the SET programme. The Board is responsible for the quality assurance of assessment within SET. Procedures that the Board uses to achieve this include evaluation of tests and test plans with advice from the faculty's educational advisors, as well as annual sampling of both internship reports and theses to check the quality of the project as well as its assessment.

The panel interviewed the Board of Examiners during the site visit and studied documentation on the Board's activities and procedures. It concludes that the Board is professional and fulfills all its legal duties in an appropriate way. There is a solid system of checks and balances. The regular checks of courses, internship reports and graduation projects provide the Board with a solid view on assessment quality in SET and the exit level of students. The panel learnt that there is a fixed agenda point at each Board meeting dedicated to SET, as the programme is much smaller in student numbers than the Mechanical Engineering programmes. The panel appreciates this and thinks this is a good measure to ensure that sufficient attention is being paid to SET in the Board meetings.

Thesis assessment

The final project is carried out in one of the research laboratories of the cooperating faculties under supervision of a professor from one of the research groups participating in the MSc. A second supervisor is added from one of the other participating groups to support the multidisciplinary character of the programme. The thesis is assessed by a graduation committee that includes both supervisors and an external member from a research group unrelated to the thesis project. Guests without voting rights, such as an external supervisor in the case of an external project, can be added to the committee. The committee is chaired by a full professor from the research group in which the student graduates; if the supervisor is not a full professor, the chair is a third member of the committee. Each thesis is graded on five aspects: Quality of research or design, Report, Working process during the master assignment, Oral presentation and Defense. The final grade is a weighted average of these five criteria, with the additional requirement that at least the first three aspects need to receive a sufficient score before a student can graduate.

As part of the assessment the panel studied 15 graduation projects of the programme and the accompanying assessment forms. The panel concludes that the thesis assessment procedure is appropriate, using a balanced composition of the graduation committees. The use of an external member not associated with the project adds to the validity of the assessment. Thesis assessment criteria are well-defined and coherent, with useful rubrics that help examiners grade theses in a comparable way. This clearly answers to the recommendations of the previous panel, which advised the use of such rubrics. The grades are appropriate and in line with the observations of the panel. The panel felt that in some cases there could be more written feedback on the forms and recommends ensuring that all examiners take their time to fill out the forms with more extensive feedback. The panel noted with appreciation that the integration of engineering and socio-economic aspects of technology is apparent in every thesis (see also standard 4). The panel observed that the assessment of this aspect varies between theses. It gives the programme into consideration to structure this better, for instance using a separate (sub)criterion related to knowledge integration and multidisciplinary.

Considerations

The panel concludes that the MSc SET has a solid assessment system that promotes reliable, valid and transparent student assessment. It includes varied assessment methods that fit the programme goals and require students to integrate their knowledge and skills, as well as an assessment plan, guidelines and

manuals, and a system of checks and balances by the Board of Examiners. Sufficient attention is paid to the individual obtainment of the ILOs in the case of group projects. Assessment of the graduation projects is appropriate, with solid procedures for composition of the graduation committees and a clear use of assessment criteria and rubrics. To further improve thesis assessment, the panel recommends paying attention to more extensive written feedback on the assessment forms, and investigating whether a separate assessment criterion for knowledge integration and multidisciplinary can be used.

Conclusion

The panel concludes that the programme meets standard 3.

Standard 4. Achieved learning outcomes

The programme demonstrates that the intended learning outcomes are achieved.

Findings

To determine the exit level of students, the panel studied 15 recent graduation projects of the programme, taking care that a variety of grades and topics was covered. It concludes that the theses are of good quality, and clearly show that students have achieved the MSc level required by the programme. The theses have a strong technical content and are clearly related to real-life technical challenges, often also inspired by concrete industrial and societal challenges.

The panel noted with appreciation that there is a relation with the socio-economic perspective visible in all theses, as required in the preparatory phase of the project. It did note that the way this is addressed in the theses was variable: sometimes fully integrated in the project and sometimes as an add-on to the discussion. It recommends finding a way to harmonize this (as discussed under standard 3).

Based on a recent alumni survey and interviews with alumni during the site visit, alumni feel well-prepared for their future career. The programme also informed the panel that internship companies often report that they are happy with the performance of students. Some alumni mentioned that while they were satisfied with the overall knowledge and skills they obtained in the programme, they would have liked more opportunities to develop a distinctive profile with more specialization options. Recommendations to pay more attention to this are included under standard 1 and 2. According to the panel, the performance and general appreciation of SET by alumni form further proof that graduates of the programme achieve the intended learning outcomes of SET.

Considerations

The good quality of the theses, as well as the feedback of alumni, convinced the panel that students of the MSc SET achieve the intended learning outcomes. Further improvements to the theses can be made by working towards a better structuring of the integration of engineering and socio-economic aspects in all theses.

Conclusion

The panel concludes that the programme meets standard 4.

General conclusion

The panel's assessment of the MSc SET is positive.

Development points

1. Further develop the profile of the programme and its presentation to the outside world to highlight the strengths of the programme. Possible focus points are the strong emphasis on socio-economic aspects of the energy transition, the small-scale nature of the programme and specific energy research domains that Twente has a strong position in.
2. Create a SET Industrial Advisory Board to provide the programme with regular external input, for instance on the new profile.
3. Continue with the plans to create more room for specialization, so that students can develop a more distinctive profile within SET. Next to the planned 'wild card system' this can include stimulating students to think about their future career as early as the start of the curriculum, and offering a smaller, more focused set of 'core electives', which can be more closely associated with the programme.
4. Develop further possibilities for students to self-diagnose possible knowledge gaps, so they have the option to remedy these prior to or in the early stage of a course.
5. Further improve thesis assessment by paying attention to more extensive written feedback on the assessment forms and introducing a more structured approach to the integration and assessment of multidisciplinary in the theses.

Appendix 1. Intended learning outcomes

A Master of Science graduate of the SET degree programme:

1. is qualified to degree level within the domain of 'science engineering & technology'.
2. is competent in the relevant domain-specific discipline(s), namely Sustainable Energy Technology, i.e.
 - 2.1 has a thorough understanding of at least one sub-area of Sustainable Energy Technology and is able to maintain and expand his/her expertise in this field.
 - 2.2 has 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.
 - 2.3 can 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 decentralized system (like a building) or the society as a system with opportunities and barriers for the development of sustainable energy technologies.
 - 2.4 is able to contribute to discussions about complex matters related to the introduction of sustainable energy.
3. is able to conduct research and design independently.
4. has the ability and attitude to include other disciplines in their research, where necessary
5. has a scientific approach to complex problems and ideas.
6. possesses intellectual skills that enable them to reflect critically, reason and form opinions.
7. has the ability to communicate the results of their learning, thinking and decision-making processes at an international level.
8. is aware of the temporal and social context of science and technology (comprehension and analysis) and can integrate this context in their scientific work.
9. in addition to a recognizable domain-specific profile, possesses 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 or research problem in question.
10. has the ability and attitude to seek new potential applications, taking the social context into consideration.

Appendix 2. Programme curriculum

	QUARTILE 1	QUARTILE 2	QUARTILE 3	QUARTILE 4
YEAR 1	Core courses 15 EC	Core courses 15 EC	Core courses 15 EC	Core courses 15 EC
YEAR 2	Internship 15 EC	Electives 15 EC	Graduation assignment 30 EC	

Core courses

Quartile 1 (15 EC)	Quartile 2 (15 EC)	Quartile 3 (15 EC)	Quartile 4 (15 EC)
• Energy Conversion Technology	• Thermodynamics and Flowsheeting	• Energy, Sustainability & Society	• Wind Energy
• Designing Business Models	• Hydrogen Technology	• Solar Energy	• System Innovation & Strategic Niche Management
• Basics for Process Simulation	• Electrical Power Engineering & System Integration	• Energy Storage	• Life-Cycle Strategy

Appendix 3. Programme of the site visit

08:30 – 08:45	Welcome
08:45 – 09:30	Interview with management
09:45 – 10:30	Interview with students and alumni (including programme committee)
10:45 – 11:30	Interview with lecturers (including programme committee)
11:45 – 12:15	Interview with Examination Board
12:15 – 13:00	LUNCH
13:00 – 14:30	Thematic session
14:30 – 15:00	Deliberation panel
15:00 – 15:30	Final meeting with management
15:30 – 16:45	Draft
16:45 – 17:15	Oral feedback and closure

Appendix 4. Materials

Prior to the site visit, the panel studied 15 theses. Information on the theses is available from Academion upon request. The panel also studied other materials, which included:

- Report previous accreditation committee 2017
- Intended Learning Outcomes
- Domain specific reference framework
- Benchmark
- ILO's in relation to learning goals
- Educational vision & philosophy
- Curriculum
- Possible electives
- Programme description
- Study guidance
- Community building
- Quality assurance SET
- Teaching staff overview
- Programme development plans
- Course manuals
- Materials from selected courses
- Themes identified after SWOT Analysis
- Education and examination regulations
- Rules and regulations Examination Board
- Annual report Examination Board
- Annual report Programme Committee
- Assessment Policy
- Examiners MSc thesis
- Assessment criteria MSc thesis
- Graduation manual and checklist
- Socio-economic thesis perspective
- Procedure graduation for supervisors
- Study success
- Exit survey 2021-2022
- Alumni survey - Analysis and conclusions
- Internship assessment - Company feedback and conclusions