MSc Sustainable Energy Technology
Delft University of Technology

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Project code P2213

Contents

Summary

Standard 1. Intended learning outcomes

The panel concludes that the MSc SET in Delft has a relevant and well-developed interdisciplinary programme, combining the strengths of various faculties to provide students with a broad, integrated, and up-to-date palette of topics on sustainable energy technologies. Its intended learning outcomes are elaborate and are formulated on an academic master's level. They are clearly aligned with the expectations of the academic and professional field through the domain-specific framework of reference. Further alignment is achieved through the broad internal and external network of the programme, which includes an Industry Advisory Board.

Standard 2. Teaching-learning environment

The panel concludes that the curriculum of the MSc SET is well-designed, and balances disciplinary and interdisciplinary content, as well as allowing students to integrate their knowledge and skills. Multidisciplinarity and system integration are key characteristics of the programme and are apparent throughout the curriculum. The programme translated the ILOs into an attractive and flexible topic-based curriculum. It guides students towards coherent ways to adapt the curriculum to their own preferences through the profiles and profile clusters on relevant topics in sustainable energy technology. The newly envisioned track on Heating & Cooling adds a whole new range of topics for students to specialize in and is designed in a careful and thorough way. Content related to the socio-economic aspects of the energy transition are apparent throughout several courses. The panel recommends further structuring these aspects to ensure that all students encounter these topics in a comparable way. The panel is positive about the choice to offer the programme in English, as this aligns with the need to address the challenges related to the energy transition in an international environment. This is implemented in a satisfactory way, with explicit attention paid to sufficient command of English by students and staff, and a balanced composition of the international classroom.

The programme has admission criteria in place to ensure that the curriculum is feasible for all admitted students. It actively helps students align their curriculum choices with their disciplinary background to prevent and if necessary, remedy knowledge gaps. There is a vibrant SET community, which forms a strong informal environment of student support, which is supplemented by a formal student support system. Students consider the workload to be manageable, with additional study duration often caused by the desire to pursue additional extracurricular courses and activities. The teaching staff is well-qualified, both in terms of research and didactic expertise, and is appreciated by students. The programme actively works on creating a SET community with a shared approach distributed among several faculties and creates opportunities for teaching staff members to meet and align. The panel considers this to be an asset of the programme and encourages the programme management to keep working on maintaining and increasing these interdisciplinary networks.

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 an elaborate assessment plan, varied assessment methods that fit the programme goals, and a system of checks and balances by the Board of Examiners. The programme strives towards continuous development of assessment and uses input from various sources to keep improving assessment quality. Sufficient attention is paid to the prevention of freeriding in group projects. Thesis assessment is appropriate, with solid procedures for composition of the graduation committees and a

clear grading scheme. The panel noted with appreciation that the new version of the assessment form encourages more written qualitative feedback.

Standard 4. Achieved learning outcomes

The high quality and relevance of the theses, as well as the feedback and career prospects of alumni, convince the panel that students of the MSc SET achieve the intended learning outcomes.

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 June 29 2023, the masters programme Sustainable Energy Technology of the Delft University of Technology 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 Twente University, 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 2019 – 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 TU Delft.

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 Delft University of Technology 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;
- Jasper Lagendijk, student Sustainable Energy Technology, Eindhoven University of Technology – Student member.

Information on the programme

Name of the institution:	Delft University of Technology
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:	Delft
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) at Delft University of Technology (TU Delft) is an interfaculty programme bringing together topics from the sustainable energy field. The programme aims for its graduates to be system integrators in the energy field, particularly regarding the transition towards sustainable energy. To realize this, the programme focuses on the different parts of the energy system, such solar and wind energy, energy transport and energy storage, as well as on the integration of those parts in an energy system. It is a broad programme in the sense that it covers a wide range of general topics related to energy systems and requires students to combine several subjects in a multidisciplinary approach. Depth is attained by specializing in a specific profile and a topic within this profile.

Compared to the other two SET programmes in the Netherlands, the MSc at TUD focuses on generation, transport, and storage of electrical energy, as well as the load in electrical energy systems. The programme is coordinated by the Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS), with participation of research groups from the faculties of Aerospace Engineering (AE), Applied Sciences (AS), Mechanical, Maritime and Materials Engineering (3ME), and Technology, Policy and Management (TPM). A steering group consisting of representatives of the five faculties involved in SET develops the vision and position of the programme. An Industry Advisory Board with representatives of various companies and institutions related to sustainable energy meets once per year to provide the programme with external input.

Per September 2023, a new track on Heating & Cooling will be added. The focus of this new track will be on the transition towards sustainable heating and cooling of the built environment, and the associated thermal energy systems. Two additional faculties will join the SET programme, namely the faculties or Architecture and the Built Environment, and Civil Engineering and Geosciences.

The panel studied the profile and aims of the programme and discussed these with various programme representatives during the site visit. It was impressed by the relevant and well-developed interdisciplinary profile of the programme, preparing students to be system integrators in the transition towards sustainable energy. Throughout the interviews the panel noted that the programme is embedded in a strong ecosystem within TU Delft and beyond and uses the input from this ecosystem to continuously develop the MSc and keep it up-to-date. The programme combines the strengths of TU Delft research throughout the faculties with the societal needs in the energy transition and translates this to a topic-based approach where students get acquainted with a wide range of relevant topics regarding sustainable energy technologies. The programme is for instance currently discussing the introduction of topics on digital energy, green hydrogen, and battery storage, and is in the final stages of adding the Heating & Cooling track, which draws two additional faculties into the SET programme. The panel thinks that these are relevant additions to the programme and supports this flexible approach towards the programme's profile and aims.

The panel praises the programme for its continuous dialogue with TU Delft researchers and external stakeholders on the relevant research topics to supplement the SET portfolio. This is a clear follow-up of the recommendations of the previous site visit, where the panel advised a stronger involvement of the professional field in formulating the programme's objectives. The panel learnt that the programme is also connected to life-long learning initiatives such as the Delft Extension School and associated MOOCs. This allows the programme to further connect to stakeholders in industry and society, in addition to its own Industry Advisory Board. The panel recognizes that it is not easy to establish an interfaculty, interdisciplinary programme, but notes with appreciation that the MSc SET at TU Delft has built up a strong position in this regard. It encourages the programme to continue these successful efforts. Regarding a further expansion of the SET network, the panel considers the Delft Energy initiative a very promising development that can catalyse further interfaculty collaboration on energy research and education.

Intended learning outcomes
Together with the MScs Sustainable Energy Technology at Twente and Eindhoven, 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 using definitions based on international criteria and compared their respective programmes. The DSFR has been translated by each of the three institutions into a set of Intended Learning outcomes (ILOs). The TU Delft formulated 7 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 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 an elaborate 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.

Considerations
The panel concludes that the MSc SET in Delft has a relevant and well-developed interdisciplinary programme, combining the strengths of various faculties to provide students with a broad, integrated, and up-to-date palette of topics on sustainable energy technologies. Its intended learning outcomes are elaborate and are formulated on an academic master's level. They are clearly aligned with the expectations of the academic and professional field through the domain-specific framework of reference. Further alignment is achieved through the broad internal and external network of the programme, which includes an Industry Advisory Board.

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 MSc SET at TU Delft contains five main elements: a common core (17 EC), the System Integration Project (7 EC), Profiles and Profile Clusters (36 EC), electives (15 EC) and the Graduation Project (45 EC). See appendix 2 for an overview. The *common core* consists of five courses that aim to teach students general knowledge within the energy field and provide them with the necessary skills in system optimization. This is followed by the *System Integration Project*, where students work in groups to design an energy system for a particular region (village, town, island), given certain boundary conditions (wind fields, solar irradiance, etc). They learn the basis of circuit analysis and modelling microgrids, as well as design and presentation skills.

After these common elements, students continue with the *Profile and Profile Cluster* courses. Students choose three out of seven profiles (Wind Energy, Solar Energy, Energy from Biomass, Power Engineering, Energy Storage, Economics & Society or Electric Mobility) and follow three courses (12 EC) for each profile. The programme does not allow students to freely combine profiles. Instead, the MSc has organized the profiles into eight coherent, themed sets, the so-called profile clusters. For instance, the Wind Economics profile cluster combines the Wind Energy, Power Engineering and Economics & Society profiles. A full overview of the eight profile clusters is provided in appendix 2. Furthermore, a study load of 15 EC is reserved for *electives*, where students can choose between multiple optional curriculum elements, such as profile electives related to one of the three chosen profiles, entrepreneurship courses, an extra project, a joint interdisciplinary project where students from multiple MSc programmes work on an industry challenge, or an internship. Students that choose an internship carry out a three-month project at a company or research institute in the Netherlands or abroad, aimed at obtaining experience in projects in a professional environment.

The curriculum is completed with the graduation project. This project is performed under supervision in one of the research groups associated with the profile cluster chosen by the student, or at a company under supervision of a TUD research staff member. It is an individual research project, which is required to have a system integration element. This means that the topic chosen by the student should always be studied in relation to energy systems. This aspect of the thesis was strengthened in response to the recommendations of the previous accreditation committee. The thesis is supervised by a professor (assistant, associate or full) from the research group. In the case of interdisciplinary topics, the student can have a second supervisor from another group.

The curriculum of the new track Heating & Cooling was in the process of design and nearing completion at the time of the site visit. This track will follow the same design principles as the current curriculum (which will be called the Electrical Energy track per 2023-2024) and will introduce new profiles as well as profile clusters related to sustainable heating and cooling in the built environment and industry.

The panel studied the curriculum and a selection of courses and discussed them with various programme representatives during the site visit. The panel appreciates the well-designed curriculum. It offers a careful balance of disciplinary and interdisciplinary content: students use the disciplinary foundation from their BSc degree to build towards an interdisciplinary profile in sustainable energy technologies. The common core

provides students with a solid basis in sustainable energy topics, whereas the System Integration Project allows students to integrate the knowledge and skills taught in the common core. In an overview provided by the programme, the panel noted with appreciation that the intended learning outcomes are used in the design of the curriculum, showing that all ILOs are incorporated in the courses as recommended by the previous accreditation panel. This overview is a living document, that is continuously updated to ensure the coherence of the curriculum regarding the ILOs in the light of curriculum changes. The panel saw in the documentation that the new Heating & Cooling track is set up using the same system as the current Electrical Energy track and is the result of a solid design process. It praises the programme for its careful and thorough approach in adding new elements to the curriculum.

The panel is positive about the many options students have to shape the curriculum to their own preferences. The profiles and profile clusters are tools to assist students in building a coherent curriculum towards specific topics, which the panel thinks are very helpful in guiding students through the many possibilities. The connection of profiles in a limited set of profile clusters allows for crossovers and interdisciplinary work, without compromising coherence. Further options for broadening or specializing are offered through the electives and optional internship. The panel noted with appreciation that the internship has dedicated learning objectives for the MSc SET and is aimed at making students familiar with the role of a SET engineer in an organizational practice.

The panel noted many elements in courses as well as the theses related to the socio-economic aspects of the energy transition, such as topics related to user behaviour and social acceptance of technologies. It also noted that, while all students encounter societally oriented topics in their profile to some extent, there can be differences between students depending on the profile and elective courses that students choose. It recommends pursuing a more structured approach to ensure that students encounter these topics in a more comparable way, for instance by adding elements to courses followed by all students (common core and key profile courses).

Didactics and language of instruction
The educational methods of SET are aimed towards multidisciplinarity and system integration. Students get acquainted with multiple disciplines and are taught to connect them to the design of energy systems. Next to more traditional lectures with instruction sessions, there are several lectures with project tasks, where students carry out a project alongside the lecturers. Skills education is mainly embedded in the core courses and System Integration Project. The core includes courses on MATLAB programming and technical writing, and the System Integration Project covers professional skills such as teamwork and presentation skills. Research skills are spread throughout the various core and profile courses, and most prominently featured in the graduation project.

The panel is positive about the didactics of the MSc SET. Multidisciplinary and systems integration skills are key characteristics of a SET engineer and are apparent throughout the core elements of the programme, particularly the System Integration Project. The panel concludes that the recommendations of the previous panel to increase attention to these elements in the curriculum have clearly been followed up. Furthermore, sufficient attention is paid to academic and professional skills in the courses and projects. During the site visit, panel and programme representatives discussed how to cover professional skills more explicitly in the curriculum, as the programme wants to make better visible where these skills are practiced (and assessed). The panel thinks that it would help to specify separate skills in the ILOs and/or course objectives, such as writing, presenting and teamwork, and link these to specific courses and assignments. This would allow for creating a more precise overview of skills education in the curriculum.

The curriculum (as well as the name) of SET is in English. This is not only the case due to its international character, but also because a large part of graduates will be active in an international industrial or academic context. The energy transition is a global challenge, that requires collaboration on a global level. The programme has a very diverse influx, with around 50% international students. To maintain this balance, the programme strives for a 50-50 admission of Dutch and international students. Furthermore, the programme aims to compose a diverse international student body, with students from fully industrialized as well as developing economies. 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. Furthermore, it is positive about the aim for a balanced international student body, in order to include multiple cultural perspectives in the international classroom.

Guidance and feasibility
The programme actively promotes the formation of an MSc SET community of students. Students have their own study association, Delft Sustainable Energy Association (DSEA), under the wing of the study association for Electrical Engineering. This association organizes frequent meetings, helping students feel at home at the university and within the programme. Furthermore, the programme organizes several information meetings for students throughout the year, helping students choose their profiles and graduation topic, and prepare for their master thesis. Additional individual support is provided through the programme coordinator and academic counsellor.

Students can be directly admitted to the programme from a wide range of BSc backgrounds. The programme's Admissions Committee has a list of national bachelor's degrees that give direct access. In other situations, the Admissions Committee decides based on the content of the BSc degree whether the student is eligible. An eligible degree should have at least 100 EC of exact sciences or engineering content, which includes a minimum of 20 EC in mathematics. In addition, international students need to demonstrate a sufficient command of English. To help students bridge possible small gaps between their background knowledge and the core or profile courses, the programme management stimulates students to catch up on this knowledge on their own. For chemistry and electrical engineering, extracurricular online courses are available that students can use to this end.

The panel is positive about the guidance and student support within the programme. Students told the panel during the site visit that the SET programme has a strong student community that, even though they are spread over various profiles and electives after the common courses, frequently meets in both study-related and social community activities, often organized by DSEA. Students also indicated that there is peer support, where students from various backgrounds help each other with courses. This informal system is supplemented by a formal support system offered by the programme. The panel has the impression that this works very well, and that the strong community is an important asset of the SET programme in Delft that has improved in an impressive way since the previous accreditation.

According to the panel, the admission criteria as well as the opportunities to remedy possible knowledge gaps, support the feasibility of the curriculum, and ensure that students can follow the core courses. The panel learnt that students self-select suitable topics that best match their backgrounds. The programme management provides students with an overview of which profiles and profile clusters are best aligned with which disciplinary background, to prevent knowledge gaps. In case students still want to pursue topics further away from their own background, the programme provides them with suggestions for additional (extracurricular) study materials and online courses. The panel considers this to be transparent without being too restrictive.

The average study duration in SET is approximately 2,5 years (28 months). This has dropped slightly since the previous accreditation (from 30 to 28 months average). The programme took measures to improve feasibility based on recommendations of the previous panel. Admission criteria have been made stricter in the past years regarding engineering and mathematics proficiency, and the thesis trajectory has been streamlined with stricter deadlines. The students confirmed to the panel that the workload is manageable, and that additional study duration is often associated with students voluntarily following more than 120 EC to get more out of the programme. The panel considers the feasibility of the MSc SET to be appropriate and praises the effort of the programme to improve this.

Teaching staff

The teaching staff is composed of members from five different faculties, adding up to a teaching team of approximately 30 lecturers for the core and profile courses. Nearly all of those are assistant, associate or full professors in one of the research groups associated with SET, are active researchers, and have a University Teaching Qualification (UTQ). Furthermore, all teaching staff members need to be able to demonstrate sufficient command of the English language through a language assessment. The programme aims for its education to be closely associated with research and innovation, as the energy field is changing fast, making it important for students to be exposed to current issues in the field.

After studying an overview of lecturers associated with the MSc SET and interviewing several teaching staff members, the panel is impressed by the quality and dedication of the teaching staff. There are sufficient teaching staff members associated with the courses, and there is sufficient attention paid to professionalization, as demonstrated in the high percentage of UTQ-qualified staff members (over 85%). The teachers are valued by students for their approachability, didactic skills and the ability to connect research, industrial and societal applications and education.

The programme management actively works on creating a community of SET lecturers throughout the different faculties of the TU Delft. There are regular meetings where staff members meet and interact. These are both formal meetings such as those to align the content of the profiles, and social activities such as those organized by the study association where students also participate. The programme management is aware of the challenges associated with working with a group of teachers distributed over multiple departments and tries to create a strong SET community and SET profile throughout the courses. The panel thinks that the programme is successful in this, and encourages the programme management to keep this up, as the increasingly developing field of energy technologies will make these interdisciplinary networks even more important.

Considerations

The panel concludes that the curriculum of the MSc SET is well-designed, and balances disciplinary and interdisciplinary content, as well as allowing students to integrate their knowledge and skills. Multidisciplinarity and system integration are key characteristics of the programme and are apparent throughout the curriculum. The programme translated the ILOs into an attractive and flexible topic-based curriculum. It guides students towards coherent ways to adapt the curriculum to their own preferences through the profiles and profile clusters on relevant topics in sustainable energy technology. The newly envisioned track on Heating & Cooling adds a whole new range of topics for students to specialize in and is designed in a careful and thorough way. Content related to the socio-economic aspects of the energy transition are apparent throughout several courses. The panel recommends further structuring these aspects to ensure that all students encounter these topics in a comparable way. The panel is positive about the choice to offer the programme in English, as this aligns with the need to address the challenges related to

the energy transition in an international environment. This is implemented in a satisfactory way, with explicit attention paid to sufficient command of English by students and staff, and a balanced composition of the international classroom.

The programme has admission criteria in place to ensure that the curriculum is feasible for all admitted students. It actively helps students align their curriculum choices with their disciplinary background to prevent and if necessary, remedy knowledge gaps. There is a vibrant SET community, which forms a strong informal environment of student support, which is supplemented by a formal student support system. Students consider the workload to be manageable, with additional study duration often caused by the desire to pursue additional extracurricular courses and activities. The teaching staff is well-qualified, both in terms of research and didactic expertise, and is appreciated by students. The programme actively works on creating a SET community with a shared approach distributed among several faculties and creates opportunities for teaching staff members to meet and align. The panel considers this to be an asset of the programme and encourages the programme management to keep working on maintaining and increasing these interdisciplinary networks.

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 EEMCS. This policy describes the faculty's vision on assessment, its organization and its quality assurance mechanisms. These include the use of the four-eye principle in designing exams, and the use of rubrics communicated to students beforehand. The programme uses an assessment plan that translates the assessment policy of the faculty into assessment practices within the SET programme.

A central element in SET assessment is that students are educated as interdisciplinary system integrators. The assessment methods should therefore provide sufficient opportunities for students to develop and demonstrate knowledge and skills related to this. Therefore, assessment methods include several group projects where students work on real-world challenges where they integrate knowledge obtained in the programme. This is complemented by individual exams and assignments to demonstrate the obtainment of the programme's ILOs on an individual level. The assessment plan contains an overview of the different types of assessment in relation to the programme's ILOs. The internship is assessed as pass/fail based on a scientific report and an evaluation report where students reflect on their role as SET engineer in daily practice. The TU Delft supervisor assesses both reports, in consultation with the external supervisor.

The panel studied the assessment system of SET, including the assessment policy of the faculty, the assessment plan, and an overview of assessment methods per course. It concludes that the programme has a solid assessment system, with sufficient attention towards valid, reliable, and transparent assessment. The assessment plans are elaborate, and detail how each ILO is assessed throughout the courses. The assessment methods are varied, and include group work, design projects and written products. The assignments require students to integrate knowledge and skills from various disciplines, in line with the aims

and educational methods of the programme. The panel appreciates that the internship places emphasis on the professional role of students, and that the pass/fail grading allows for students to focus on their personal development rather than high grades.

The student chapter of the self-evaluation report mentioned that students would like further opportunities for formative assessment during courses in the form of mid-term assessments . During the site visit the panel got mixed messages from staff and students as to whether this was necessary and desirable. The panel got the impression, also based on student comments, that there is already considerable attention paid to formative feedback. It recommends investigating this issue further to see whether any changes are necessary.

Due to the high prevalence of group projects in the MSc, the panel discussed the risk of freeriding with various programme representatives. The programme explained that courses that use group projects generally also have an individual exam to ensure that students also individually attain the course objectives. Furthermore, peer assessment and the observation of the group supervisors are used to make individual deviations from the group grade possible if necessary. The students told to the panel that they feel that assessment in group projects is fair and takes all relevant aspects into account. The panel is positive about the attention to reliable and valid group assessment in the programme.

Board of Examiners
The MSc SET has a dedicated sub-board within the faculty wide EEMCS Board of Examiners. This sub-board consists of five members representing the five participating faculties. The faculty-wide Board covers general assessment policies, whereas the sub-board deals with programme-specific requests, issues, and quality checks. One member of the sub-board represents SET in the faculty-wide Board of Examiners. Quality checks include the check of the programme assessment plan, regular screening of course assessment, as well as annual sampling of MSc theses.

The panel interviewed the Board of Examiners during the site visit and studied several reports describing the work of the Board. It got the impression that the Board is competent and professional and has solid quality assurance mechanisms in place. These mechanisms cover the course level (regular course assessment review), the programme level (input and checks on the programme assessment plan) and the exit level of graduates (annual thesis sampling). It noted that the programme in general strives towards continuous development of assessment quality and uses student input and results of checks and reviews to keep assessment in the programme at a high level.

Thesis assessment
The MSc thesis is graded by a graduation committee that consists of at least three examiners appointed by the Board of Examiners. Amongst its members should be at least one full professor, one examiner familiar with the profile and requirements of SET (a so-called ‘green list’ examiner) and examiners from two different research groups. The thesis is graded in a committee deliberation after the thesis defense. Six different criteria are graded, namely Theoretical Knowledge, Method and Approach, Work, Report, Presentation and Defense, and Competences. The grades are issued using a detailed rubric, describing the level required for a specific grade.

As part of the assessment the panel studied 15 final 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 that ensures sufficient affinity with the SET programme. Assessment criteria are well-defined and coherent, and students are well-informed on what is

expected, both in terms of process, content, analyses, presentation, and contribution. The grades are appropriate and are in line with the observations of the panel. The panel felt that in some cases there could be more personal feedback on the forms. It learnt with appreciation that the programme will introduce a new version of the thesis assessment form, that addresses this through a format that encourages more written qualitative feedback. The panel studied this new version and agrees that this version creates more room for comments and substantiation.

Considerations

The panel concludes that the MSc SET has a solid assessment system that promotes reliable, valid and transparent student assessment. It includes an elaborate assessment plan, varied assessment methods that fit the programme goals, and a system of checks and balances by the Board of Examiners. The programme strives towards continuous development of assessment and uses input from various sources to keep improving assessment quality. Sufficient attention is paid to the prevention of freeriding in group projects. Thesis assessment is appropriate, with solid procedures for composition of the graduation committees and a clear grading scheme. The panel noted with appreciation that the new version of the assessment form encourages more written qualitative feedback.

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

Prior to the site visit, the panel studied 15 recent theses of the MSc SET, taking care that a variety of grades and profile clusters was covered. It concludes that the theses convincingly show that students achieve the programme's intended learning outcomes. The studies are well-executed, with solid empirical or modelling research, and with comprehensive and detailed conclusions. The theses showed the integration of multiple disciplines, and included a strong real-world component, as well as socio-economic reflections on the relevance of the technologies for the energy transition, answering to the recommendations of the previous panel.

Graduates of the programme are generally highly appreciated, as evidenced by the feedback of alumni during the site visit, the annual alumni surveys, and the feedback from the Industrial Advisory Board. Alumni usually quickly find a suitable position in industry, consultancy or as a PhD candidate on topics related to the energy transition, and generally feel that the programme helped them prepare for this. The panel considers this further evidence of the high exit level of students.

Considerations

The high quality and relevance of the theses, as well as the feedback and career prospects of alumni, convince the panel that students of the MSc SET achieve the intended learning outcomes.

Conclusion

The panel concludes that the programme meets standard 4.

General conclusion

The panel's assessment of the MSc Sustainable Energy Technology is positive.

Development points

1. Pursue a more structured approach to ensure that students encounter topics related to the societally relevant aspects of the energy transition in a comparable way throughout the courses.
2. Keep up the successful efforts in developing an interdisciplinary network on sustainable energy-related topics, as the increasingly developing field of energy technologies will make these networks even more important.

Appendix 1. Intended learning outcomes

1. Scientific discipline
The student has knowledge and skills in disciplines of Sustainable Energy Technology and the attitude to apply these independently in the context of more advanced ideas and applications. This consists of:

a. mastery of at least three advanced subject areas within the field of Sustainable Energy Technology (such as topics in Solar Energy, Wind Energy, Energy from Biomass, Energy Storage, Power Engineering, Electric Mobility, and Economic and Society).
b. the ability to make connections between and to integrate different subject areas within the field of Sustainable Energy Technology.
c. theoretical and practical skills to apply methods for truth-finding, theory development, modelling, interpretation, experimentation, simulation, reflection, and decision making, independently.

2. Doing research
The student is able to perform research independently that contributes to the development of scientific knowledge about the application of sustainable energy technologies to address complex, energy-related problems. This consists of:

a. the ability to analyse research problems and to formulate answerable research questions.
b. practical skills and the attitude to set up and carry out research and/or draw up and implement draft plans.
c. the ability to reflect critically on the research of others and themselves, and to draw upon disciplines from other fields where necessary.

3. Designing
The student is able to create independently designs for sustainable energy technologies to address complex, energy-related problems. This consists of:

a. the ability of understanding a wide variety of different problems and to formulate these at an abstract level, whilst being able to see the relation between diverse problems at this abstract level.
b. the capability of creating innovative technical designs, taking technical, economic and social feasibility issues into account, and with a focus on practical applications.
c. knowledge of integration of energy technologies and of techniques to optimise the design of integrated energy systems and their parts.
d. awareness of the applicability of research in technological developments.

4. Scientific approach
The student has a systematic approach, characterised by the development and use of theories, models and coherent interpretations, has a critical attitude and has insight into the specific nature of science and technology related to sustainable energy technology.

5. Intellectual skills
The student has intellectual skills befitting an academic graduate. This includes:

a. the ability to reflect critically on their own research, thinking, and acting.
b. the capability of formulating and defending opinions on research, design and developments in sustainable energy.

6. Co-operating and communicating

The student is capable of working in interdisciplinary teams, performing research or design activities and communicating easily in English, both in writing and orally. This includes:

a. exhibiting professional behaviour.

b. the attitude and skills to perform project-based team work that addresses complex and interdisciplinary problems.

c. the capability to present clearly their research results, to communicate with colleagues and to present results at conferences or as (part of) a publication to varied audiences, while being aware of the background and interest of the audience.

7. Temporal and social context

The student takes the consequences into account of their activities on society and vice versa. This includes:

a. having sufficient understanding of the role of science and engineering in society to be able to reflect on this and develop an ethical attitude and practice their profession accordingly.

b. having knowledge of economic aspects of the energy system and of policy instruments that can influence these economic aspects.

c. having knowledge of sustainable energy-related developments in society.

Appendix 2. Programme curriculum

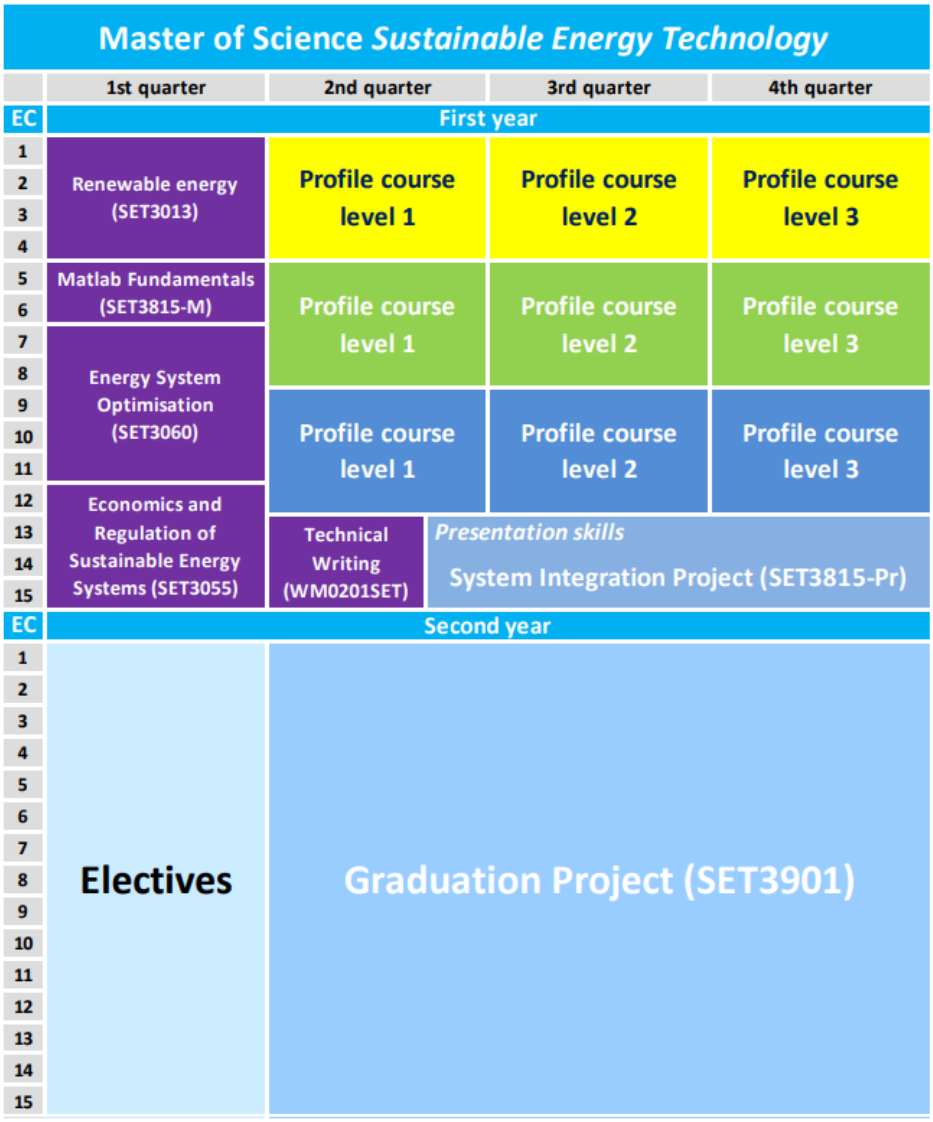

Figure 2. The *Module Chart* for the MSc SET programme.

Wind Energy	Introduction to Wind Turbines: Physics and Technology	Site conditions for Wind Turbine Design	
		Wind Turbine Design	
Solar Energy	Photovoltaic Basics	Photovoltaics Technologies	Photovoltaics Systems
Biomass	Thermochemistry of Biomass conversion	Multiphase Reactor Engineering	Green Chemistry and Sustainable Technology
Power	Electronic Power Conversion	Intelligent Electrical Power Grids	Choice: Electrical Power Systems of the Future or DC and AC Microgrids
Storage	The Necessity of Storage Technology	Energy Storage in Batteries	Hydrogen Technology
Economics & Society	Sustainable Energy Innovations and Transitions	Economic Policy for Sustainable Energy	Technology, Entrepreneurship and Sustainability
Electric Mobility	Electrical Machnies and Drives	Electrical Vehicle and Charging Technology	Digital Modelling of Electric Powertrain

Figure 4. The courses that make up each profile.

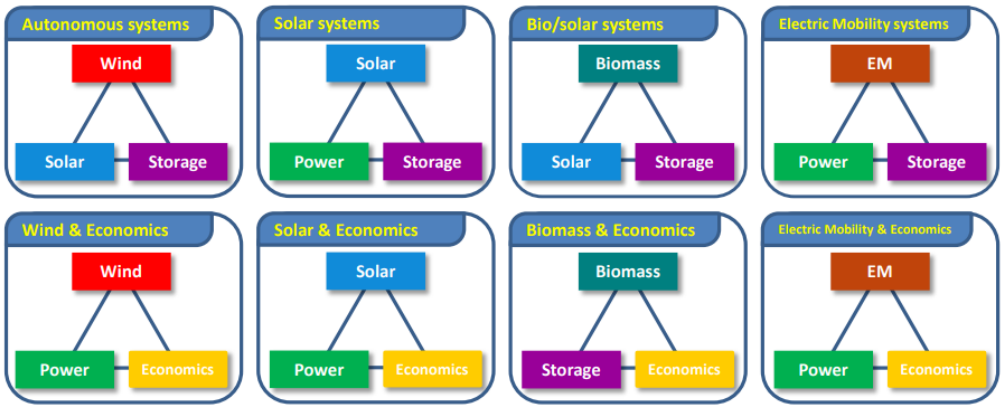

Figure 5. The composition of the *Profile Clusters* offered in the MSc SET programme.

Appendix 3. Programme of the site visit

Thursday 29 June 2023

08.30-09.00	Preparation panel
09.00-10:00	**Session programme management**
10:00-10:15	Break
10.15-11.15	**Session students and alumni**
11.15-11.30	Break
11.30-12.30	**Session teaching staff**
12:30-13:15	Lunch panel
13:15-13:45	**Session Board of Examiners**
13:45-14:00	Break
14.00-14.30	Internal panel session
14.30-15.00	**Concluding session management**
15.00-16.15	Internal panel session
16.15-16.45	**Feedback and conclusion presented by the panel**

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:

- Programme description MSc Sustainable Energy Technology
- Student chapter
- Report previous accreditation committee 2017
- MSc SET - SWOT analysis
- Information on influx and study duration
- Information on the addition of the Heating and Cooling track
- Teaching and assessment material and from selected courses
- Domain-Specific Reference Framework
- Benchmark study
- Intended Learning Outcomes MSc SET
- Education vision and principles of the programme
- Overview lecturers and their qualifications
- Teaching and Examination Regulations EEMCS 2022-2023
- Overview information meetings for SET students
- Information page Internship SET
- Information page Graduation Project
- Assessment policy of the faculty of EEMCS
- Rules and Regulations of the EEMCS Board of Examiners 2022-2023
- Assessment review cycle EEMCS
- Programme assessment plan SET
- Current and new thesis assessment grading scheme and rubrics
- MSc SET alumni survey 2021 and 2022
- TU Delft - University alumni survey 2021 and 2022
- Minutes Industry Advisory Board meetings 2020-2021
- Annual reports Board of Examiners 2020-2021 and 2021-2022
- Annual reports Board of Studies 2020-2021 and 2021-2022
- Annual report Quality Assurance 2020-2021 and 2021-2022