



**MSc Sustainable Energy Technology**  
**Eindhoven University of Technology**

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Project code P2213

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## Summary

### Standard 1. Intended learning outcomes

The panel concludes that the MSc SET in Eindhoven has a strong and relevant research-oriented profile. It aims for students to integrate engineering and socio-economic skills into a multidisciplinary approach towards sustainable energy technologies. Students develop into T-shaped professionals by specializing in a sustainable energy-related topic after having obtained multidisciplinary core knowledge and skills. As a next step in the continuous development of the programme, the panel encourages the MSc SET to further develop this profile and strengthen its ambitions as an interdisciplinary programme that connects departments on energy-related research topics. There are already several promising bottom-up collaborations between research groups that the programme could build on to realize a topic-based approach rather than a research group-based approach in the specialization phase of the curriculum. The panel therefore has full confidence that the programme is well-positioned to further develop its interdisciplinary ambitions. The intended learning outcomes of the programme are appropriate and are 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. The panel recommends setting up a dedicated SET Industrial Advisory Board to provide the programme with regular external input to further strengthen the link of the programme with the professional field.

### Standard 2. Teaching-learning environment

The panel concludes that the MSc SET has translated its intended learning outcomes into a well-structured and coherent curriculum. The core curriculum provides students with a broad basis in sustainable energy technologies and provides them with the skills to integrate this knowledge. The specialization profiles provide students with relevant and attractive opportunities, with the academic mentors helping students to create a coherent individual curriculum of profile courses, electives, internships, and the graduation project. The SELECT dual degree promotes the international character and focus of the programme and is well-incorporated into the regular SET curriculum. 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 to sufficient command of English by students and staff. The curriculum is feasible, with appropriate attention paid to the prerequisite knowledge of students. The teaching staff is well-qualified, both in terms of research and didactic expertise, and is appreciated by students.

In the current set-up of the curriculum, the associated research groups are largely responsible for shaping the content of the profiles, as well as individual curricula and graduation projects of students. The panel thinks that the programme would benefit from pursuing a more holistic SET approach in the specialization part of the curriculum to strengthen its multidisciplinary and integrative character. This could be promoted by delaying the choice of a specialization until students have completed most of the core curriculum, shifting towards a topic-based approach where students choose a (multidisciplinary) topic for specialization rather than a single research group, culminating in a multidisciplinary research project, and by empowering the academic mentors to create links between research groups and act as ambassadors of the programme. An added benefit of pursuing a shared SET approach throughout the entire curriculum is that it promotes community-building between SET students and staff members, while creating opportunities for interdepartmental collaborations between staff members.

### Standard 3. Student assessment

The panel concludes that the MSc SET has a solid system of assessment, with solid assessment procedures and quality assurance mechanisms, and a variety of assessment methods that fit the aims of the programme. The Examination Committee fulfils its legal duties and is very active in quality checks of courses and theses. The theses are assessed in a valid, reliable, and transparent way, with appropriate rules for the composition of graduation committees, and the use of transparent assessment criteria in grading. The unified SET approach to assessment is clearly visible in the core curriculum, which convinced the panel that all students are assessed on all ILOs of the programme in an appropriate way. Extending this SET approach to the specialization part of the curriculum is still a challenge for the programme, due to the large number of departments and research groups involved. The panel recommends to nevertheless keep pursuing this and strive towards multidisciplinary and integration throughout the entire curriculum, including all graduation projects. Next to the abovementioned development of the SET profile and community, this could be achieved by introducing more requirements for SET principles in the thesis topics and adding the associated assessment criteria to the thesis assessment forms.

### Standard 4. Achieved learning outcomes

The panel concludes that the quality of the theses as well as the experiences of graduates and their employers clearly show 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 28 June 2023, the master's programme Sustainable Energy Technology of Eindhoven 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 the institutions 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 taking into account 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 in 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: 11 from the regular SET programme and 4 from the SET SELECT dual degree programme. 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 finalized the report, and the coordinator sent it to the TU Eindhoven.

## 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 Legendijk, master student Sustainable Energy Technology, Eindhoven University of Technology – Student member.

The panel assessing the MSc Sustainable Energy Technology at Eindhoven 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;
- Cassandra Post, master's student Sustainable Energy Technology, University of Twente – Student member.

## Information on the programme

Name of the institution:	Eindhoven 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:	Eindhoven
Joint programme:	Track SELECT (Dual degree with KTH (Stockholm, Sweden) and UPC (Barcelona, Spain))
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 Eindhoven University of Technology (TU/e) is a multidisciplinary, interdepartmental programme focused on the technological challenges associated with the energy transition. Students study the design, behaviour and performance of energy technologies, as well as their implementation. The programme does not only focus on renewable energy sources such as wind, solar or bioenergy, but also combines this focus with attention paid to issues such as efficiency, storage and transport of renewable energy, and economic and societal aspects of energy. Graduates of the programme can work as academic engineers working on the energy transition. Compared to the other two SET programmes in the Netherlands, the MSc at TU/e predominantly focuses on energy storage, smart electricity grids, sustainable energy systems in the built environment and on embedding sustainable energy systems in a socio-economic context. The MSc is coordinated by the department Mechanical Engineering of TU/e, with participation of the departments Electrical Engineering, Industrial Engineering & Innovation Sciences, Built Environment, Chemical Engineering & Chemistry and Applied Physics & Science Education. SET is embedded in the TU/e Graduate School, which sets the guidelines and structures for MSc level education at TU/e.

The panel studied the programme's profile and aims and discussed them with various representatives during the site visit. It concludes that the SET programme at TU/e has a strong and relevant research-oriented focus. Students can specialize in several relevant sustainable energy-related topics at the associated departments, building on a multidisciplinary basis provided in the core of the programme, and developing into so-called T-shaped professionals. At the same time, the panel noted that this research-oriented focus has its associated challenges. Students are embedded into the research groups associated with the programme for the larger part of the programme. This limits the extent to which the programme can fully exploit its multidisciplinary and integrative focus outside the core of the programme, as the extent to which students pursue this approach depends on the thesis topic and the supervisor. This was apparent in the theses the panel studied (see standard 4), which formed a mix of multidisciplinary and more monodisciplinary research topics.

During the site visit the panel learnt that the programme management is contemplating its position and unique selling point. In the Graduate School, research groups are largely responsible for educating master's students in a master-apprentice type relationship. This can create differences between the profiles of individual students, as not all research groups are closely related to the aims and multidisciplinary profile of the SET programme. The programme management wonders to what extent it can impose the SET profile on the participating research groups without losing their support for the programme. The panel understands this struggle, but also thinks that it can be turned into an opportunity. The nature of the SET programme can be used to formulate its unique selling point as an interdisciplinary master's programme that spans research groups. The programme would then not focus on the T-shaped professional, but rather on the Π-shaped professional. These professionals study technology in context: integrating a broad basis in sustainable engineering technologies with specialization in both engineering and socio-economic aspects of a specific technology. This multidisciplinary and integrative approach is also one of the main reasons students mentioned to the panel for choosing this programme.

During the site visit, the panel learnt that there are already several bottom-up initiatives where researchers from multiple groups work together on topics related to sustainable energy technologies, sometimes brought together by SET students that want to specialize in a multidisciplinary topic. The panel thinks these initiatives are prime examples of what the unique selling point of the programme could be. It encourages the programme to build on these initiatives, and develop these into a topic-based approach, where students choose a multidisciplinary topic rather than a research group to specialize in over the course of the programme. Several ideas to implement this were discussed between panel and programme during the thematic sessions of the site visit.

#### *Intended learning outcomes*

Together with the MScs Sustainable Energy Technology at Twente and Delft, the MSc SET in Eindhoven 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, see appendix 1). The TU/e ILOs have been divided into generic ILOs that are shared among all MSc programmes at TU/e, describing general skills of an academic engineer, and programme-specific skills describing the specific knowledge and skills relevant for a SET graduate. 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 programme's intended learning outcomes. 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 appropriate 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. The ILOs reflect the research-focused and multidisciplinary approach of the programme. The panel noted with appreciation that the programme has many links to external stakeholders in industry and society, and often uses these links to informally discuss the alignment of the programme with that of the professional field. The panel encourages the management to further structure these contacts into a dedicated SET Industrial Advisory Board that provides the programme with regular advice concerning its profile, aims and curriculum.

#### *Considerations*

The panel concludes that the MSc SET in Eindhoven has a strong and relevant research-oriented profile. It aims for students to integrate engineering and socio-economic skills into a multidisciplinary approach towards sustainable energy technologies. Students develop into T-shaped professionals by specializing in a sustainable energy-related topic after having obtained multidisciplinary core knowledge and skills. As a next step in the continuous development of the programme, the panel encourages the MSc SET to further develop this profile and strengthen its ambitions as an interdisciplinary programme that connects departments on energy-related research topics. There are already several promising bottom-up collaborations between research groups that the programme could build on to realize a topic-based approach rather than a research group-based approach in the specialization phase of the curriculum. The panel therefore has full confidence that the programme is well-positioned to further develop its interdisciplinary ambitions. The intended learning outcomes of the programme are appropriate and are 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. The panel recommends setting up a dedicated SET Industrial Advisory Board to provide the programme with regular external input to further strengthen the link of the programme with the professional field.

## 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 SET is organized along the design principles of the Graduate School of TU/e, where all MSc programmes are embedded. This means that the programme consists of core courses (30 EC), specialization (15 EC), elective space (30 EC) and a graduation project (45 EC). For SET, 15 EC of the elective space are dedicated to the mandatory internship. See appendix 2 for an overview of the curriculum.

In the *core courses* (30 EC), students follow four compulsory courses during the first semester that help them understand the challenges and themes in energy supply and the system perspective required to engineer and design solutions. The core curriculum is concluded by the System Integration Project in the second semester, where students work in teams on a real-life assignment from a (societal or industrial) partner from the network of the research groups, connecting the knowledge acquired in the courses to an actual energy issue, and developing their academic and professional skills.

Over the course of the first semester, students select one of six *specialization* profiles, as well as a research group associated with this specialization. The six profiles are Electrical power systems, Application in the built environment, Energy & society, and three profiles related to Sources, fuels & storage (Chemistry for sustainable energy systems, Engineering for sustainable energy systems and Systems for sustainable heat). Students follow 15 EC of specialization courses within their profile. These are intended as preparation for the graduation project and are composed in consultation with their academic mentor in the chosen research group. Academic mentors are staff members from the research group and profile of choice, who help students realize their individual learning objectives and compose their individual curriculum. They advise students on the choice of specialization courses, electives, an internship, and a graduation project, and on submitting this individual curriculum to the Examination Committee for approval.

Within the specialization profile, 15 EC of courses are considered to be *free elective space* and can be used in any way the students and their mentors see fit, such as homologation courses, further specialization or one of the international exchange programmes (see below). Specialization is further developed through the *internship*, where students work on a topic that fits their personal profile and obtain experience in a working environment. The position is chosen in consultation with the student's mentor and can take place in a company or a research institution in the Netherlands or abroad, depending on the student's individual learning objectives. Specialization is concluded by the *graduation project*, where students work individually on a research project under supervision of a staff member of one of the chosen research groups. The project is usually carried out within the group but can also be executed at one of the group's research partners.

The panel studied the curriculum of the MSc SET as well as the content of several courses. It is positive about the content and structure of the curriculum. The core courses provide a solid multidisciplinary basis in sustainable energy technologies, and the System Integration Project teaches students how to integrate

various perspectives. Furthermore, the panel appreciates the opportunities for specialization through the specialization profiles, internship, and graduation project. The six specializations are attractive and relevant to the field of sustainable energy technology. The curriculum incorporates all ILOs in an appropriate way, as demonstrated in an overview presented to the panel, which addresses the recommendation given by the previous panel to map this in a more detailed way. The panel also appreciates the attention paid to real-world challenges in the didactics of the programme, particularly in the Systems Integration Project. The panel learnt that the Graduate School is working on increasing this by further embracing challenge-based learning in the MSc programme, which it considers to be a good fit for the MSc SET.

As discussed under standard 1, the research groups are largely responsible for the content of the specializations. Students choose electives, an internship, and a graduation project in consultation with their mentor within the group. Students often choose multidisciplinary projects but can also choose more disciplinary topics. As students from multiple MSc programmes join research groups for their specialization, and not every group is closely associated to the SET programme, this can create differences in the way students compose and execute their SET specialization. The panel is of the opinion that the SET programme would benefit from a more holistic approach, where the specializations are more explicitly tied to the specific multidisciplinary and integrative profile and aims of SET. Although the intended learning outcomes associated to these aspects are covered in the core curriculum, the panel thinks that ensuring that students keep working on multidisciplinary topics would increase the coherence of the curriculum. This also extends to the graduation project, which the panel thinks should include integrative and socio-economic aspects to some extent for all students. This ability to consider the boundary conditions of technology in society and economics is a strength of the MSc SET and could be more prominent in the second part of the curriculum. This was also expressed by some of the students the panel interviewed, who viewed the multidisciplinary focus of the programme as its main strength and would welcome a stronger connection to SET-specific societal and industrial challenges in the graduation phase.

One of the ways the programme could achieve a more multidisciplinary second part of the curriculum is to provide more flexibility in choosing a specialization. In the current set-up, students already choose this a few weeks into the first semester. The panel thinks that it would be advisable to postpone this choice to a later moment when students have already followed a major part of the core curriculum. This could help them see more opportunities for multidisciplinary topics as well as broaden their view to include topics that are still outside of their scope at the start of the programme. An added benefit of this is that it might be easier to create a stronger community of SET students (see below), as it would shift the focus from SET to research group context to a later moment in the curriculum.

A second way to promote a holistic SET approach in the specialization phase of the curriculum would be to shift from a research group-based to a topic-based approach to specialization (as also mentioned under standard 1). The programme could create a selection of multidisciplinary topics related to sustainable energy technology for students to choose from for their specialization phase. Topics could be organized jointly by multiple research groups, building on existing and new collaborations between groups. The panel encourages the programme to develop the curriculum in this direction and seek collaboration with stakeholders outside the programme to make this possible.

Finally, the academic mentors could have an important role in promoting the SET approach. A strong group of mentors closely connected to SET could be instrumental in connecting the research groups in a topic-based approach to specialization and ensure multidisciplinary and integration with socio-economic aspects in the students' choice of topics. The panel thinks that the current teaching staff members would be

suitable for this role. They should be empowered to create connections between groups and facilitated to use the SET approach in composing the individual curricula with students.

#### *Language and internationalization*

SET is an internationally focused programme and offers students various opportunities to follow part of their curriculum abroad. It participates in the European KIC InnoEnergy SELECT programme, which is organized under the flag of EIT, the European Institute of Innovation and Technology of the EU. This dual degree programme focuses on energy technology, innovation, and entrepreneurship. It is a collaboration between the universities of Stockholm (KTH), Barcelona (UPC), Lisbon (IST), Turino (PoliTo), Aalto, Krakow (AGH) and Eindhoven.

Students in the SELECT dual degree programme follow their first-year courses in Stockholm (KTH) or Barcelona (UPC). These curricula consist of a fixed set of courses comparable to that of the first year in Eindhoven. An exception is the Systems Integration Project, that is replaced by the Integration Project of the Year (IPoY), a project organized by EIT where students from all partner universities participate. Based on the completion of these courses, students can apply for an exemption for the first-year courses upon enrollment in Eindhoven, so they can immediately follow the second-year specialization courses and conduct their graduation project. They receive their TU/e diploma based on the Eindhoven intended learning outcomes and receive a second diploma from KTH or UPC based on the learning outcomes set by these institutions. Typically, 10-15 SELECT students graduate in Eindhoven annually.

Furthermore, the MSc has established an exchange programme with the Technical University of Denmark (DTU). Students do their graduation project at DTU and in addition elective courses and/or an internship. The MSc has set up several pre-approved exchange programmes with DTU to facilitate this. The exchange is part of the TU/e curriculum: the graduation project is graded according to the TU/e system.

The panel is positive about the international collaborations of the MSc SET, which promote the international character and focus of the programme. It studied the quality assurance mechanisms in place to ensure that the SELECT dual degree programme is of a comparable level to the regular SET programme. It also learnt that there is a separate quality assurance system in place for all EIT joint programmes with an EIT label associated with a positive assessment, which is the case for SELECT. As all students perform their graduation project in Eindhoven, the programme can assess and monitor the exit level of SELECT students according to the standards of regular SET students. Based on the quality of the SELECT theses that the panel studied, as well as the on the interviews during the site visit, the panel concludes that this system works well in practice.

In line with its international character, the curriculum (as well as the name) of SET is in English. This is not only the case because of its international exchange programmes, 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 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.

#### *Guidance and student support*

Students from a wide variety of BSc engineering backgrounds can be admitted to SET. Several BSc diplomas give direct access to the MSc. For the remainder, the programme's Admissions Committee decides whether the specific courses that the student followed as part of their BSc education is sufficient preparation for SET, and whether they demonstrate a sufficient command of English. Limited deficiencies indicated by the

Admissions Committee or signaled by the students and their mentors can be remedied by following homologation courses on the topics of these deficiencies in the free elective space. To help students get acquainted with SET and studying in Eindhoven in general, all students that are new to Eindhoven get assigned a student mentor to introduce them to the university and the city.

The panel appreciates the intake procedure of the programme. The admission criteria support the feasibility of the curriculum and ensure that students are able to follow the core courses. The criteria are open enough to allow for a diverse inflow, allowing students with small deficiencies to remedy this as part of the curriculum. The panel considers a well-designed admission procedure to be important for a broad programme such as SET. It encourages the programme to keep this up, as the field can be expected to become increasingly broader rather than specialized.

During the site visit, the panel discussed community-building among students and staff with various programme representatives. This topic was also addressed during the previous site visit and remains a challenge for an interdepartmental programme such as SET. Students have recently started organizing several social activities among themselves and are investigating whether a separate student room for SET students within the building would be feasible. Students join the programme from different BSc programmes, and follow a large part of their curriculum at different departments, often with students from other MSc programmes. This is especially the case for students in the SELECT dual degree, who follow their first year outside of Eindhoven and only follow their specialization courses and the graduation project in Eindhoven. The panel supports these community-building initiatives, both from a student support and from a content perspective. A tighter community of SET-students (and staff members) would provide staff and students with a stronger identity, making it easier to promote the SET approach throughout the different departments associated with the programme. The panel thinks that working towards a topic-based approach for specialization and postponing this choice until a later time in the curriculum (as discussed under Curriculum) would be a good step towards creating such a community.

#### *Feasibility*

Students usually take between 2-3 years to finish the curriculum, which the programme deems a sign of the feasibility of the curriculum. To promote its feasibility, the programme schedules all courses in a digital system to prevent overlap in lectures and exams. All courses, except for the System Integration Project, are shared with other MSc students of the participating department. The programme has an agreement with all departments that any overlap in core courses is not permitted and is avoided as much as possible with specialization courses. Another measure to promote feasibility is the fixed duration of the graduation project (8 months maximum). The start and end date are determined when starting the execution of the project, and only one formally requested extension of maximum 10 weeks can be granted in the case of personal circumstances. This has had a very positive influence on the average study duration, as the graduation project used to be a major source of study delay. The panel is positive about the attention paid to feasibility, including the efforts to prevent scheduling conflicts and the fixed duration of the thesis project. The actual study duration shows that the curriculum is feasible, which was confirmed by students, who consider the workload of the curriculum to be appropriate.

#### *Teaching staff*

The teaching staff of the programme is employed at the six departments associated with SET, and largely consists of active researchers and engineers on energy-related topics. A group of approximately 15 staff members is responsible for the core courses, with a larger, more variable group active as lecturer in specialization courses and as academic mentor of students. The teaching staff is mostly united through participation in the Eindhoven Institute for Renewable Energy Systems (EIRES), the interdepartmental,

multidisciplinary research institute that connects research activities on the energy transition at TU/e. 60% of the teaching staff is in possession of the University Teaching Qualification (UTQ), with the rest either in the process of obtaining this, or having received an exemption based on previous experience or due to a small part-time contract. Furthermore, all lecturers are required to be proficient in English on C1 level minimum.

The panel is very positive about the quality of the teaching staff. The staff members are all active researchers and teach and supervise topics that are closely connected with their own research expertise. This allows students to be trained as researchers in a master-apprentice setup, which students appreciate. The panel notes with appreciation that since the previous site visit, the programme has stepped up its efforts to pursue teaching qualifications for all teaching staff members. All new staff members are now required to obtain their UTQ. As most departments are going through a period of growth, not all staff members have yet completed their UTQ, which is reflected in the current still relatively low percentage. The panel encourages the programme to ensure that all new staff members complete their UTQ in a timely manner to further improve this. As discussed earlier in this report, the panel encourages the programme management to further invest in a SET community of teaching staff members that embrace and promote the SET approach, to build on and expand the multidisciplinary, integrative character of the MSc SET.

### Considerations

The panel concludes that the MSc SET has translated its intended learning outcomes into a well-structured and coherent curriculum. The core curriculum provides students with a broad basis in sustainable energy technologies and provides them with the skills to integrate this knowledge. The specialization profiles provide students with relevant and attractive opportunities, with the academic mentors helping students to create a coherent individual curriculum of profile courses, electives, internships, and the graduation project. The SELECT dual degree promotes the international character and focus of the programme and is well-incorporated into the regular SET curriculum. 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 to sufficient command of English by students and staff. The curriculum is feasible, with appropriate attention paid to the prerequisite knowledge of students. The teaching staff is well-qualified, both in terms of research and didactic expertise, and is appreciated by students.

In the current set-up of the curriculum, the associated research groups are largely responsible for shaping the content of the profiles, as well as individual curricula and graduation projects of students. The panel thinks that the programme would benefit from pursuing a more holistic SET approach in the specialization part of the curriculum to strengthen its multidisciplinary and integrative character. This could be promoted by delaying the choice of a specialization until students have completed most of the core curriculum, shifting towards a topic-based approach where students choose a (multidisciplinary) topic for specialization rather than a single research group, culminating in a multidisciplinary research project, and by empowering the academic mentors to create links between research groups and act as ambassadors of the programme. An added benefit of pursuing a shared SET approach throughout the entire curriculum is that it promotes community-building between SET students and staff members, while creating opportunities for interdepartmental collaborations between staff members.

### 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 principle that the assessment method fits the learning objectives of the course, contributes to student learning, and assures achievement of the programme's ILOs. Due to the large role of individual components in the curriculum, the ILOs are fully covered in the shared curriculum components, namely the core courses, internship, and graduation project. The programme maintains a mapping of these curriculum components in relation to the ILOs, as well as an overview of the assessment methods. Assessment methods includes written exams, presentations, individual and group reports. The internship is examined by the internal supervisor from the student's research group, based on an internship report and the performance of the student during the internship, with advice from the company supervisor. The assessment policy is developed on a department level and describes several quality assurance mechanisms to ensure the reliability, validity, and transparency of assessment. Examples are co-development of tests and of assignments of courses. Group projects and individual assignments are mixed throughout the courses to ensure that students get the opportunity to develop their professional skills regarding teamwork while limiting the risk of free riding. In addition, project groups are closely supervised to increase the detection of possible imbalances between individual group members.

SET shares an Examination Committee with the master's programmes Systems & Control and Automotive Technology. The Committee is composed of six members, representing the departments associated with the three programmes. This safeguards the interdepartmental nature of SET, and the participation of all departments in the assessment policies and procedures. The Examination Committee checks the assessment plan and safeguards the assessment of courses through checks by a subcommittee (Assessment Committee) that reports to the Committee. The Committee annually takes random samples of MSc theses to check the exit level of students as well as thesis assessment.

The panel studied the assessment system of the programme and interviewed the Examination Committee during the site visit. It was impressed by the procedures and policies. The assessment methods are varied and fit the goals of the programme. The Examination Committee fulfills its legal duties in an appropriate way. The panel noted that the Assessment Committee is very active in safeguarding the quality of course assessment as well as thesis quality with regular checks.

The panel noted from discussions during the site visit that coordination of assessment policies and procedures is a challenge in a multi-department programme, where teaching staff members are often used to the assessment procedures of other departments and MSc programmes. The composition of the Examination Committee, with six members from the associated departments, aims to achieve coherence in assessment, which the panel appreciates. It recommends continuing to pursue a unified SET assessment approach so that the SET principles of multidisciplinary and system integration are visible not only in the core curriculum, but in the entire curriculum. The panel understood that the programme management is working on additional supervision and assessment manuals and templates to help the broader group of teaching staff members outside the core courses assess SET students according to the SET principles. The panel encourages this, and thinks that a further development of the SET profile and community as discussed in earlier standards will help to strengthen this aspect.



### *Thesis assessment*

The thesis project is assessed by a graduation assessment committee consisting of at least three formally appointed examiners from TU/e or another university, one of whom is the graduation supervisor. At least one of the members is required to belong to a different research group to that of the graduation supervisor. In the case of a graduation project in industry or abroad, the external supervisor can be advisor of the graduation assessment committee. The committee grades the project after the final defense by the student, based on consensus. In the assessment of the final project, they grade the thesis on seven criteria: approach and execution of the thesis work, autonomy during the project, analytical ability, inventive and creative abilities, report quality, quality of the defense and quality of the presentation. The final grade is an average of the seven subgrades. Each subgrade is required to be substantiated with qualitative motivation.

As part of the assessment, the panel studied 15 final projects of the programme and the accompanying assessment forms. The panel concludes that the theses are assessed in a reliable, valid, and transparent way. Assessment by the graduation committees is well-designed and ensures that a variety of viewpoints is included in the assessment. The grades were found to be appropriate by the panel, and sufficiently motivated through the assessment criteria. In some cases, the panel would have welcomed more feedback by the examiners. The panel recommends monitoring this more closely.

As discussed above, the programme faces the challenge of integrating assessment by a variety of supervisors from different departments into a unified SET assessment approach. This was also visible in the thesis assessments that the panel studied. The extent to which attention was paid in theses to SET principles such as the assessment of system integration and socio-economic aspects differs per thesis. This was also noted by the previous accreditation panel. The programme indicated in discussions with the panel that they considered several initiatives to address this, but that setting up an overall approach to include and assess socio-economic aspects in every thesis was unsuccessful. Not all supervisors felt that they had sufficient expertise to supervise and assess such multidisciplinary theses. The programme therefore focused on strengthening these SET principles in the core curriculum, assuring that students are assessed on all ILOs in this part of the curriculum, and allow for more disciplinary theses as the 'specialization' leg of the T-shaped professional. The panel acknowledges that a unified SET approach is difficult to achieve in the current set-up of the programme but thinks that its earlier recommendations considering the multidisciplinary and integrative character of specialization in the SET programme would be a good step towards addressing this issue. A core group of SET supervisors and a move towards multidisciplinary, possibly co-supervised graduation projects would help in more structurally embedding socio-economic aspects in every thesis. In this set-up, the programme could also place more restrictions on thesis topics to ensure that they reflect the multidisciplinary character of SET and introduce explicit assessment criteria for SET principles such as reflection on socio-economic aspects and system integration to the thesis assessment form.

### *Considerations*

The panel concludes that the MSc SET has a solid system of assessment, with solid assessment procedures and quality assurance mechanisms, and a variety of assessment methods that fit the aims of the programme. The Examination Committee fulfils its legal duties and is very active in quality checks of courses and theses. The theses are assessed in a valid, reliable, and transparent way, with appropriate rules for the composition of graduation committees. The unified SET approach to assessment is clearly visible in the core curriculum, which convinced the panel that all students are assessed on all ILOs of the programme in an appropriate way. Extending this SET approach to the specialization part of the curriculum is still a challenge for the programme, due to the large number of departments and research groups involved. The panel recommends to nevertheless keep pursuing this and strive towards multidisciplinary and integration throughout the entire curriculum, including all graduation projects. Next to the abovementioned development of the SET

profile and community, this could be achieved by introducing more requirements for SET principles in the thesis topics and adding the associated assessment criteria to the thesis assessment forms.

#### 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

In order to determine the exit level of students, the panel studied 15 recent master's theses (11 of the regular SET programme and 4 of the SELECT dual degree) of the programme, taking care that a variety of grades and specialization profiles was covered. It concludes that the theses are all of good quality, and clearly show that students have achieved the MSc level required by the programme. The theses all had topics very relevant to the sustainable energy transition. As discussed earlier under other standards, the multidisciplinary and integrative character of the theses varied. Some works had very multidisciplinary topics with included socio-economic impact of new technologies, whereas others had a more monodisciplinary character. The panel advises to develop more requirements for what a SET thesis should look like to promote the unique SET approach among students embarking on their thesis. In all cases the panel was convinced that students achieved the intended learning outcomes of the SET programme. Even if the multidisciplinary and integrative aspects of SET were not so prominent in some of the theses, the other curriculum elements safeguard that students sufficiently master this part of the ILOs.

Based on a recent alumni survey, graduates of the MSc SET feel well-prepared for the work field and feel they have acquired the skills and knowledge that are required. Employers of SET alumni were also asked about their experience with graduates of the programmes. They reported to be satisfied with the level and qualifications of their employees and are positive about their performance in general. Both alumni and employers specifically mention that the broad profile and multidisciplinary focus constitute a main asset of SET graduates. According to the panel, this is a further proof that graduates of the programme achieve intended learning outcomes of the SET programme, including the multidisciplinary and integrative aspects.

#### Considerations

The panel concludes that the quality of the theses as well as the experiences of graduates and their employers clearly show 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. Further develop the multidisciplinary and integrative character of the programme throughout the entire curriculum. Options to pursue this include:
  - a. Shift from a research-group based specialization to topic-based specialization, where students choose a multidisciplinary topic that multiple research groups contribute to. Existing collaborations between groups can be used as a starting point for this approach.
  - b. Delay the choice for a specialization until later in the curriculum, when students have completed most of the core curriculum.
  - c. Empower the academic mentors to create links between research groups and act as ambassadors of the programme.
  - d. Keep working on building a community of SET students and staff members.
  - e. Introduce requirements for thesis topics that reflect the multidisciplinary and integrative character of the programme and include criteria for this on the thesis assessment form.
2. Create a dedicated SET Industrial Advisory Board to provide the programme with regular external input.

## 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

### General structure

1st year	• Core program (30 EC)	
	• <b>Specialization courses (15 EC)</b>	
• Free electives (incl. homologation, 15 EC)		
2nd year	<b>Internship (15 EC)</b>	<b>Graduation project (45 EC)</b>

### Core program

Sustainable Energy Sources (ME, AP, 5 EC, Q2)	Electrical power engineering and system integration (EE, 5 EC, Q1)
System integration project (EE and IE&IS, 10 EC, Q3&4)	
Building performance and energy systems simulation (BE, 5 EC, Q1)	Energy, Economy & Society (IE&IS, 5 EC, Q2)

## Appendix 3. Programme of the site visit

Session	Themes	Time
Welcome and preparation		8:30-9:00
Interview management	- Short presentation by the SET Management	9:00-9:45
Studenten en alumni		10:00-10.45
Theme: Learning and teaching environment	- SET-community - SET-profile - Human Resources - Growth	11:00-12:00
Break		12:00-13:00
Theme: Teaching and assessment	- Growth - Curriculum - Assessment of group assignments - Exchange programs	13:00-14:00
Theme: Design principles of the GS & Intended Learning Outcomes -	- SET-profile - Exchange programs	14:15-15:15
Internal Panel: discussion		15:15-16:00
Session with management		16:00-16:15
Internal Panel: drafting judgments		16:15-16:45
Short presentation of the findings and opportunity for informal meetings		16:45-17:15

## 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
- Report previous accreditation committee 2017
- Student chapter
- Overview SELECT track
- Information on influx and study duration
- Teaching and assessment material and from selected courses
- Domain-Specific Reference Framework
- Benchmark study
- Admission requirements and procedures
- Overview of research groups involved in the SET programme
- Intended Learning Outcomes MSc SET
- Education vision
- Overview lecturers and their qualifications
- Teaching and Examination Regulations
- Manual Internship SET
- Manual Graduation Project
- Assessment policy of the Mechanical Engineering department
- Current and new thesis assessment grading scheme and assessment criteria
- MSc SET alumni survey 2023
- MSc SET employer survey 2023
- Annual reports Examination Committee
- Annual education reports
- SWOT analysis
- Revision document SET