# 2024 Evaluation Report

## Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS)

## Departments:

- Electrical Sustainable Energy (ESE)
- Microelectronics (ME)
- Quantum & Computer Engineering (QCE)

## TU Delft

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**Preface**

Electrical Engineering (EE) is one of the most dynamic and fast-growing engineering disciplines and has created a major impact on our society in the past 100 years. It has enabled the use of computers, wireless communications, radar sensing, electric vehicles, advanced medical equipment, smart grids, and so on. Many future societal challenges will depend on new developments in the area of Electrical Engineering. Therefore, high-quality scientific research in this area is extremely important.

Electrical Engineering at Delft University of Technology (TU Delft) has always been at the forefront of engineering research in many areas. As a result, TU Delft educates the next generations of engineers and equips them with the required expertise and skills needed to make them effective in our competitive society. To maintain and further optimize the research quality at TU Delft, an international committee has been constituted and has been given the task to assess the performance of the Electrical Engineering departments over the past six years. Next to this, the committee has assessed their viability in the next years and provides the Board of TU Delft with recommendations on how to optimise their scientific future.

It has been a privilege for the entire committee to interact with the three EE departments and to visit the renovated EE building and corresponding research labs. The site visit was prepared very well by providing an extensive self-assessment report.

This report provides a detailed overview of the Committee's activities, and offers analysis, conclusions, and recommendations. It is the result of an intense and productive interaction between the committee and the staff members of the three departments and management of the EEMCS Faculty. On behalf of the committee, I would like to thank all site-visit participants for their constructive, enthusiastic, effective, and constructive contributions. We hope that the evaluation and our recommendations will contribute to further optimizing the research in the area of Electrical Engineering at TU Delft.

On behalf of the entire evaluation committee,

Prof.dr.ir. Bart Smolders
Chairman

## 1. Executive summary

The mission of the EEMCS Faculty and the three departments of Electrical Engineering (EE) is to contribute to two large societal transitions: (1) replacing fossil fuels with renewable energies, and (2) digitalization of society and industry. Next to these Themes the Faculty also focuses on the Theme Health & Well-being. The committee regarded this mission highly relevant and observed that EE is well-connected to major industries in the world.

During the site visit, the committee met very dedicated scientific staff members, support staff and PhD candidates. The demonstrations of the laboratories were all very impressive while the research facilities are regarded as excellent. The committee valued the funding raised for research projects and infrastructures. Also, the significant growth of the departments over the last six years was greatly appreciated. Publications in top journals and contributions to high-profile conferences evidenced the quality of the research performed within the departments. The strategy for the coming six years showed that the three EE departments are in good shape and viable to cope with the challenges ahead.

There are, however, some issues about which the committee has serious concerns, and which need improvements in the coming years. The main ones are the following.

Above all, the committee is very concerned about the PhD program and the quality of supervision. Although the previous Evaluation committee already recommended to shorten the duration of PhD trajectories and to increase the success rates of PhD graduations, there has been no sign of improvement since. Even the ambition in the strategy for the next six years (70% of the PhD candidates should graduate within five years) is judged as very low in this regard. Next to this, the guidelines for PhD candidates towards graduation appeared not clear to them, while the Graduate School noticed a lack of urgency among supervisors to take their task more seriously. The committee heard many (mostly different) ideas and solutions to solve this issue.
See also observations section 4.1.1 point 3.

Secondly, the committee observed limited cooperation and strategic alignment among the three EE departments, as well as towards the other departments of the EEMCS Faculty. There is too little evidence of sharing best practices and ownership of cross-departmental themes is missing. As a result, joint initiatives to connect to large opportunities, such as the Chips Act and the National Growth Fund (NGF), are not well exploited.
See also observations section 4.1.1 point 2.

Thirdly, although the Self-Assessment reported (page 12) that "*EEMCS researchers are both curiosity-driven and application-inspired*", the committee noticed an imbalance between fundamental research and applied research. This appeared e.g. from the large proportion of projects for industry and the relatively low proportion of projects from NWO or ERC as well as the relatively low value for the Field-Weighted Citation Impact (FWCI) within EE's field of research. Since EE also advocates Quality above Quantity of its publications, and citations are mentioned as key indicators for use of its products, it is remarkable that a publication strategy to improve EE's citation impact did not appear to exist. As a University of Technology (i.e. not a University of Applied Sciences), it is expected that TU Delft focuses on answering scientific questions to solve societal problems in the future. Emphasising fundamental research will therefore help to improve the chances for the funding of grants aiming at scientific breakthroughs. Such projects will also contribute to a better visibility of the EE departments within the international scientific community.
See also observations section 4.1.1 point 4, section 4.2.1 point 4, section 4.2.2 points 1 and 4, section 4.2.3 point 4 and 7, and footnote on page 23.

Fourthly, the committee highly appreciated the new Academic Career Track HR policy and start-up packages for newly hired staff members. It is observed, however, that HR policies are interpreted differently by the departments and that there is no transparency about the path to promotion, especially to full professor.
See also observations section 4.2.1 point 8 (one but last paragraph).

Fifthly, a final point of attention concerns the relatively low number of spin-off companies as compared to other EE departments of technical universities in Europe.
See also observations section 4.2.1 point 7 and section 4.2.2 point 7.

**Most important recommendations**

1. *PhD success rate and duration*
   a. Create an EE-wide (for all three departments) PhD policy to improve the success rate and address the issues at hand.
   b. Include (financial) incentives for student and supervisor to complete in 4 years (e.g. bonus after defence of thesis).
   c. Consider to define fair policies for contract extension for those who do not manage to finish in 4 years.
   d. Define clear guidelines for PhD students about what is required to finish the PhD; these must clearly be communicated.
   e. Define clear leadership.
   f. Clarify the role, responsibility and mandate of the EEMCS Graduate School, also vis à vis the individual PhD promotors.

2. *Collaboration among departments*
   a. Act strategically towards large opportunities such as the Chips Act/National Growth Fund.

3. *Publication strategy*
   a. Review the publication strategy and related field weighted citation metrics on a yearly basis and use results strategically.
   b. Consult peers, e.g. Wageningen University & Research (WUR), where a focused publication strategy resulted in great improvements of citation impact.

4. *Acquisition of research funding*
   a. Stimulate and improve proposals targeting grant programs for more fundamental research, such as NWO and ERC grants (e.g. by peer support, training and consulting grant agencies).

5. *Hiring technicians and long-term funding and maintenance of research facilities*
   a. Establish a creative and pro-active recruitment team for hiring qualified technicians.
   b. Prioritize the needs for upgrading or buying new equipment frequently and search pro-actively for funding this.

# 2. Introduction

## 2.1 Aim of the evaluation

All publicly funded university research in the Netherlands is evaluated at regular intervals in compliance with a national evaluation protocol (*Strategy Evaluation Protocol*; SEP2021-2027), as agreed by the Association of Universities of the Netherlands (UNL), the Netherlands Organisation for Scientific Research (NWO) and the Netherlands Academy of Arts and Sciences (KNAW). The evaluation process, which is applied at the research unit level, consists of an external peer review conducted every six years.

This research quality cycle aims to achieve three generic objectives:

- to assess a research unit in light of its own strategy and aims, including the sufficiency or appropriateness of the aims and strategy;
- to monitor and improve the quality of research, societal relevance and viability of the research unit;
- to contribute to fulfilling the duty of accountability towards government and society.

This evaluation deals with the performance of three departments belonging to the *Faculty of Electrical Engineering, Mathematics and Computer Science* (EEMCS) of the Delft University of Technology (TU Delft) namely *Electrical Sustainable Energy* (ESE), *Microelectronics* (ME), and *Quantum & Computer Engineering* (QCE).

The committee is requested to assess the research in the context of its (inter)national field of science as well as its PhD training (retrospective: 2017-2022) and identifies ways for further improvement (prospective: 2023-2028). Specifically, the committee is asked to judge the performance of each department, and to offer its written conclusions as well as recommendations based on considerations and arguments.

## 2.2 The evaluation process

The research evaluation as set out in the SEP2021-2027 for public research organisations is based on three central criteria:

- *Research quality*: the quality of the unit's research over the past six-year period, in light of its own aims and strategy;
- *Societal relevance*: the societal relevance of the unit's research in terms of impact, public engagement and uptake of the research;
- *Viability*: the extent to which the research unit's goals for the coming six-year period remain relevant both scientifically and societally.

According to the SEP2021-2027, also the following *four specific aspects* should be taken into account: (1) *Open Science*, (2) *PhD Policy and Training*, (3) *Academic Culture* and (4) *Human Resources Policy*.

In addition to the above mentioned criteria and specific aspects, the Board of TU Delft has asked the Committee to answer two supplementary questions:

A. How can the Electrical Engineering departments align their research agendas with Europe's research agenda, the Chips Act and the next Framework Programme?

B. How can we further empower early and mid-career scientists?

Six weeks before the site visit, the Committee received the Terms of Reference in which the task and expectations of the Committee are described. Also, a copy of the SEP2021-2027 was provided as a supporting tool for this evaluation. It further received a narrative self-evaluation report (including appendices with evidential documents) describing the aims, strategy and performance of each of the three departments both for the past six years and for the next six years and in the context of their position within TU Delft and other national and international research institutions. Upon request of the committee, three more documents were provided: (1) a Field Weighted Citation Impact analysis of EE publications (FWCI, period 2017-2022), (2) Publication Strategies EE 2017-2022 and (3) Results of surveys among PhD candidates.

The Committee was requested to report its findings in line with the three main criteria and the four additional aspects. The findings are reported separately for each department in a narrative form, and are followed by recommendations for further improvement. In the text, the considerations of the Committee are clarified, while the conclusions are summarised in an executive summary. The evaluation is based on the following evidence:

- the Self-assessment report;
- a site visit including among others interviews and lab tour with each department.

The site visit took place 4th February – 6th February 2024 and consisted of the following elements (see Programme in Annex 1):

- a meeting with the Rector Magnificus of TU Delft and Dean of the Faculty EEMCS;
- a meeting and lab tour with the Management Board of each department;
- a lunch with PhD students;
- a meeting with Tenure Track professors;
- a meeting with representatives from the EEMCS Graduate School;
- a final plenary debriefing meeting for EEMCS staff members during which the Chair of the Committee presented the preliminary conclusions of this evaluation.

All meetings except the tour along research facilities were with the plenary Evaluation Committee.

The Evaluation Committee is composed by seven peer members including the Chair, an independent PhD student from another Dutch university and an independent secretary.

The Committee consisted of the following persons:

- Prof.dr.ir. A.B. (Bart) Smolders, Eindhoven University of Technology (Netherlands, Chair);
- Prof.dr. M.S. (Maria Sabrina) Greco, University of Pisa (Italy);
- Dr. A. (Artur) Podobas, KTH Royal Institute of Technology (Sweden);
- Prof.dr.ir G.E. (Georges) Gielen, KU Leuven (Belgium);
- Prof.dr.ir. R. (Roel) Baets, Ghent University (Belgium);
- Prof.dr. H. (Hele) Savin, Aalto University (Finland);
- C. (Clara) Otero Perez MSc, NXP (Netherlands);
- Ir. T.H. (Tariq) Bontekoe, University of Groningen (Netherlands, PhD student);
- Dr. C. (Chris) Mollema (Netherlands, Secretary).

All Committee members signed a statement of impartiality and confidentiality declaring that they would judge without bias, personal preference or personal interest, and that their judgement is made without undue influence from persons or parties committed to the departments under review. Although interviews were jointly prepared and performed with all Committee members, individual members were asked to take the lead in particular sessions and the resulting draft text of the Committee's findings.
Bio-sketches of the Committee members are presented in Annex 2. Their findings and recommendations are described in chapter 4 of this report.

The final draft of the Evaluation Report was sent to the Executive Board of TU Delft to check for factual inaccuracies. In the end, the final Report was sent to the Executive Board.

**2.3 Follow-up on previous Evaluation**

The suggestions made in the previous evaluation and in the mid-term evaluation have all been addressed in the self-assessment report. However, two key recommendations still lack progress: 1) Although the strategic impact on NL and EU funding has improved in the past years by strengthening the internal collaborations within the three EE departments, the committee still advices to also show more leadership in taking up the coordination of large NL and EU programs, such as the national Growth Fund. The committee is also very positive about the installed research committee to facilitate the acquisition of personal grants. This should lead to an increase in personal grants in the next evaluation period and improve joint actions for strategic impact at NL and EU level, and 2) PhD program, in particular the duration and success rate. Both items will again be included in our recommendations for the upcoming period.

## 3. Structure, organisation and mission of Electrical Engineering departments

### 3.1 Introduction

The Delft University of Technology (TU Delft) is one of the four Technical Universities in the Netherlands, which together established a federation called 4TU (also including Eindhoven University of Technology, University of Twente and Wageningen University). These universities cooperate intensively in several areas such as Electrical Engineering and have created a joint funding programme for specific investments. In addition, TU Delft has regional strategic alliances with TNO Research (e.g. the joint research institute for quantum computing and quantum internet, *QuTech*), Leiden University, Erasmus Medical Centre and Erasmus University Rotterdam. Also internationally TU Delft is well-embedded among partner institutions such as the IDEA League, consisting of five European universities of technology, science and engineering (TU Delft, ETH Zurich, RWTH Aachen, Chalmers University of Technology Gothenburg and Politecnico di Milano).

The *Faculty of Electrical Engineering, Mathematics and Computer Science* (EEMCS) is one of the eight Faculties of TU Delft. The Faculty EEMCS has six departments. Next to the three departments belonging to Electrical Engineering (*Electrical Sustainable Energy*, *Microelectronics* and *Quantum & Computer Engineering*), there are two departments in Computer Science (Software Technology and Intelligent Systems) and one Mathematics department (Delft Institute of Applied Mathematics). The main research themes identified within EEMCS are 1) *health and well-being*, 2) the *energy transition,* and 3) the *transition of our digital society*. There are also a number of cross-border, interdisciplinary key technology areas such as *communication and sensing*, *Artificial Intelligence (AI)* and *unconventional computing/quantum technologies*. Next to the overarching Faculty themes, other themes coexist within the departments, such as *cyber security*, *semiconductors* and *agrotech*.

EEMCS staff and students have access to a broad spectrum of research facilities and specialised laboratories. For example, in 2021 the Electrical Sustainable Power Lab opened, located in the former High-Voltage Lab building and the Else Kooi Laboratory (cleanroom).

Since research and education are heavily intertwined within EEMCS, its staff contributes significantly to teaching programmes for Bachelor and Master students. The education programmes cover the fundamental disciplines in electrical engineering, mathematics and computer science, and offer exploration of interdisciplinary fields such as computer engineering, embedded systems, data science and artificial intelligence, sustainable energy technologies, biomedical engineering and technical medicine. Besides, EEMCS staff contributes to the TU Delft Extension School for Continuing Education. This School develops and delivers online education. Its courses and short programs especially support lifelong learners and professionals to upskill themselves in areas of technical and engineering expertise of great relevance to the environment and society.

### 3.2 Mission and Strategy

TU Delft's overarching motto is "impact for a better society". As part of this university as well as the Faculty EEMCS, some of the EE departments' missions, goals and operations have collectively been defined. In section 3.2.1 – 3.2.3 the specific strategy of the individual EE departments are described.

EEMCS strives towards a technology-driven impact, contributing to scientific breakthroughs and technological innovations that can address societal challenges in a global context. Its mission is summarized as follows:

- To perform cutting-edge research in electrical engineering, mathematics and computer science resulting in revolutionary technologies and novel computational techniques;
- To provide a stimulating environment for high-quality education and training of responsible engineers in electrical engineering, mathematics and computer science.

EEMCS also strives to be among the best in the world and have the aspiration to be an equally good employer. Research at EEMCS focuses on developing novel, sometimes revolutionary, engineering solutions and technologies. It seeks to push the boundaries of scientific knowledge, conducting fundamental and innovative research in computer science, mathematics and electrical engineering. EEMCS researchers are both curiosity-driven and application-inspired, working together to provide innovative, responsible technologies for societal challenges and some of the main transitions of our times.

For the *four specific aspects* mentioned in section 2.2, TU Delft developed shared policies across all Faculties.

*Open Science:*
TU Delft wishes to take Open Science to the next level with the Open Science Programme 2020-2024, Research and Education in the Open Era, aiming at making Open Science the default way of practising research and education. Key policies, guidelines and services on Open Science include:

- TU Delft Policy on Open Access Publishing;
- TU Delft Research Data Policy Framework;
- Support by the team of TU Delft data stewards, including a dedicated EEMCS Data Steward.

Open Access (OA) publishing has become more or less a given as TU Delft makes most publications openly and freely accessible through the TU Delft Institutional Repository and other aggregators in a published or earlier version. Additionally, TU Delft has made agreements with major publishers about OA publishing.

*PhD Policy and training:*
PhD students who start in a TU Delft research department also enrol in the Graduate School. The Graduate School consists of the TU Delft Graduate School and the Faculty Graduate Schools of the respective Faculties. The Faculty Graduate Schools coordinate the Faculty PhD policy, which consists of, among other things, guidelines for the selection and interim evaluation of PhD candidates, support for promotors and the objectives and guidelines for research and discipline-specific courses. The Graduate School prepares and trains doctoral candidates to become highly qualified, autonomous, leading researchers and skilled professionals through the Doctoral Education Programme. It also monitors the process of annual progress meetings of PhD candidates, including a go/no-go decision one year after the start. It coordinates the appointment of promotors and the evaluation and defence of doctoral dissertations.

PhD students have the opportunity to participate in policy development through PhD Councils, such as the University PhD Council and the EEMCS PhD Council, which discuss issues and concerns with the Graduate Schools and Management.
TU Delft follows the national policy to offer PhD candidates a four-year position. According to the Self-assessment report, TU Delft aims for 70% of PhD students to obtain their degree within five years.

*Academic Culture:*
Concerning openness, (social) safety and inclusivity, TU Delft strives to be both a leading university and a great place to work. To achieve this, it supports the following core values: Diversity, Integrity, Respect, Engagement, Courage, and Trust (DIRECT). These core values are embedded across the TU Delft community and manifest while working, studying and socialising together. The TU Delft Code of Conduct describes these core values. Social Safety and Inclusivity are parts of Social Integrity, promoted in the TU Delft policies and activities on integrity and coordinated by the Integrity Office, established to help the TU community with their questions on integrity and what to do in the case of a specific query or complaint. The topic of Inclusivity is shared with the Diversity & Inclusion Office.

The TU Delft Integrity Office has a dedicated Policy Advisor for Academic Integrity, which includes Research Integrity, Research Ethics and Educational Integrity. The Integrity Office works closely with research units on research ethics and integrity. Key policies, guidelines and services in this domain include the TU Delft Regulation on Complaints about Research Integrity. The Integrity Office also provides specific expertise in the European and Netherlands Codes of Conduct for Research Integrity.

*HR Policy:*
TU Delft embraces diversity and aims to be as inclusive as possible. To promote this, TU Delft has founded a Diversity & Inclusion (D&I) Office in 2021 with dedicated policy advisors on these topics. The D&I Office is in close contact and works with various student and staff networks in TU Delft, including the EEMCS Diversity and Inclusion Team (EDIT).

Regarding talent management, TU Delft aims to attract and recruit talented people, create excellent teams and give employees the room to discover and develop their talents. TU Delft endorses the principles of the European Charter for researchers and the European Code of Conduct for the recruitment of researchers.
In 2019, TU Delft started the programme Recognition and Rewards as part of the national Recognition & Rewards Initiative. Important elements of the programme are the option to pursue academic careers with an emphasis on education instead of research and the replacement of TU Delft's Tenure Track with the Academic Career Track (ACT).
Researchers are encouraged to develop themselves in the areas of research, education, valorisation and leadership. TU Delft expects that everyone displays personal leadership in performing their role. Leadership skills training is offered at different career stages.
EEMCS generally follows TU Delft's standard HR procedures, but it has a special procedure for appointing persons to the position of Associate Professor. In this procedure, the so-called Career Development Committee (CDC) advises the dean on the suitability of a nominated Assistant Professor or external candidate to be promoted to or appointed as Associate Professor.

### 3.2.1 Mission and strategy of the Department of Electrical Sustainable Energy (ESE)

The mission of the department ESE is to accelerate the energy transition towards sustainable energy. It is ESE's ambition to be a leading academic player in the energy transition with focus on sustainable energy and digitalization of the future energy system. The ESE department is mission-driven. All organisational sub-units share one and the same vision: a clean, affordable, resilient, and fair power system.

The department's research focus is aligned within the themes of the Faculty EEMCS, where the Energy Transition is one of three overarching research themes. In addition, three key technologies, including Artificial Intelligence as an enabling technology, are identified as focus areas for the EEMCS Faculty.

The strategic aims of ESE for the period 2023-2028 are:

- Happy personnel with distinguished expertise;
- High-quality and attractive education;
- Impactful research;
- State-of-the-art research and educational infrastructure;
- Healthy project portfolio;
- Broad and functional network with industrial partners.

The ESE department promotes FAIR data practices and open-source software. At the same time, it applies strong data security practices.

### 3.2.2 Mission and strategy of the Department of Microelectronics (ME)

ME's vision and strategy are in line with those of TU Delft and the Faculty EEMCS. The main aim of the department is to develop electronic technology that addresses societal and industrial needs in a global context. The department will contribute by expanding and disseminating fundamental knowledge and collaborating with industrial partners to enable the large-scale application of this knowledge. In a world with multi-disciplinary challenges, it aims for system-level solutions. ME also aims to create value from knowledge by making it suitable or available for economic or societal use and translating it into products, services, processes, and entrepreneurial activity.

ME aims to publish its scientific results in peer-reviewed journals (preferably open access) and conferences. Apart from regular project funding sources (e.g. NWO), it also aims to participate in large interdisciplinary programmes, e.g. strategic national investment programmes (National Growth Fund, Gravitation Fund), and European funding opportunities (ECSEL). In addition, eligible staff are encouraged to apply for personal excellence grants (Veni, Vidi or ERC).

ME's researchers are curiosity-driven and application-inspired, working together to provide innovative, responsible technologies for societal (and industrial) challenges. ME's strategy is to align with and anticipate the evolving interplay between societal demands and technological progress. Societal relevance is aimed by ME's choice of research themes. ME strives to generate impact by relevant projects, patents, industry-funded projects, MSc thesis collaborations with industry, and occasional TV interviews. The department stimulates researchers to explore the potential of patented inventions for commercial purposes, and to initiate spin-offs where appropriate.

Strategic priorities of ME for 2023-2028 are:

- Strengthening its research themes and improving its visibility;
- Increasing its MSc/PhD output;
- Strengthening its experimental infrastructure;
- Integrating its fresh staff into the department;
- Creating more flexible project financing models.

### 3.2.3 Mission and strategy of the Department of Quantum & Computer Engineering (QCE)

The QCE department was established in 2016 with the initial mission to serve as the focal point for all major quantum (computing) activities within the Faculty of EEMCS, as well as the main link to QuTech. Next to developing new scientific knowledge, contribution to the EEMCS societal themes belong to the mission of QCE. The department is particularly involved in the societal themes Health & Well-being and Safety & Security.

The research of the Quantum and Computer Engineering (QCE) department focuses on *Computer Architectures* and *Network Architectures*, with the ambition to maintain its leading role among the top European research groups and to become one of the research leaders worldwide.

QCE research adopts a holistic approach in which it addresses the entire design stack (i.e., device technology, circuit design, architectures, compilers, algorithms and applications); this is done not only in order to maximise the computational efficiency but also to push the research quality further.

The research on Computer Architectures which involves neuromorphic computing, approximate computing, computation-in-memory, spin-wave computing, new hardware architectures for Artificial Intelligence, big-data architectures, and hardware dependability. It includes also the development of materials and integration techniques for quantum and classical components, the design of the electrical interfaces for quantum bits using Cryo-CMOS circuits/systems, quantum architectures, tools, and applications; The quantum related research is done in close collaboration with QuTech.

The research on Network Architectures falls in the broad domain of Network Science, which aims to understand the graph structure of networks and the dynamic processes that take place on networks. This research contributes to the fundaments of Network Science: it investigates, amongst others, geometric representations of networks, epidemic spread on networks, spectra of graphs and network algorithms. In addition, it applies its solid mathematical knowledge to the design, management and control of critical infrastructures, such as telecom networks, power grids and water distribution networks, in order to make these networks robust, resilient, efficient and reliable.

QCE has an active policy regarding attracting and maintaining talented and diverse staff members.

Strategic choices of QCE for the period 2023-2028 are:

- to strengthen its holistic, cross-layer approach focused on chip prototypes while addressing relevant societal challenges focusing on “healthcare and wellbeing” and “safety and security”;
- additional investment in technical and non-technical support;
- to fulfil a very important role in the European Chips Act;
- reinforcement of collaborations to maintain research quality and societal relevance;

- additional effort in positioning the department, especially at the national level;
- attracting top talents.

### 3.3 Management and organisation

#### 3.3.1 Department of Electrical Sustainable Energy (ESE)

The research activities of the ESE department aim to accelerate the energy transition towards a sustainable energy system and address the important societal challenges posed by climate change and environmental pollution.
The department plays a leading role in the Energy Transition research theme of the EEMCS Faculty. The research of ESE covers the generation of electricity from renewable energy sources, as well as its transmission, distribution, storage and consumption. It includes the design and fabrication of photovoltaic (PV) cells and modules and power electronic devices for future power networks. It involves the study of direct-current (DC) high-voltage (HV) transmission, electric mobility and intelligent power management systems. An important topic is the digitization of the power system to improve its planning, control and organisation.
The ESE department is organised into four sections:

- DC Systems, Energy Conversion and Storage;
- High Voltage Technologies (since 2022);
- Intelligent Electrical Power Grids;
- Photovoltaic Materials and Devices.

The ESE department has realised a new Electrical Sustainable Power Lab, which provides large-scale infrastructure to experimentally support all research activities in the department.

The department is led by a department head, who is supported by a department manager/deputy head. The ESE MT consists of section heads and lab manager plus occasional external consultants who help with specific topics.

Content-wise, the sections have full autonomy on how to develop and how to impact the energy transition best. The scoping of research areas, the definition of tenure track positions, and the strategy on infrastructure is a creative and bottom-up process.

#### 3.3.2 Department of Microelectronics (ME)

The research of the Department of Microelectronics covers nearly all aspects of electronic engineering, ranging from electromagnetics and signal processing to hardware design and from microfabrication to the realisation of complete radar arrays. It also includes the design and (micro) fabrication of electronic devices, analogue and digital circuits for smart sensors, biomedical implants, and wireless communication systems, the development of signal processing theory and algorithms for radar, communication, and biomedical applications, as well as microwave and terahertz systems for remote sensing and radio astronomy.

The department is organised into seven sections, which are mainly discipline or application-oriented:

- Bioelectronics (BE);
- Electronic Components Technology and Materials (ECTM);

- Electronic Instrumentation (EI);
- Electronic Circuits and Architectures (ELCA);
- Microwave Sensing Signals and Systems (MS3);
- Signal Processing Systems (SPS; previously Circuits and Systems (CAS));
- Terahertz Sensing (TS).

Spanning these sections, the research of the department is clustered into three interdisciplinary research themes:

- *Health and Well-Being* (HWB; also a theme of the EEMCS Faculty);
- *Next Generation Sensing and Communication* (XG; component of Faculty theme Digital Society);
- *Autonomous Sensor Systems* (ASSYST; also component of Faculty theme Digital Society).

The themes are also fitting to the Faculty key technologies: Sensing & Communication (XG, ASSYST) and Artificial Intelligence (HWB, ASSYST).

The experimental work of the three research themes is carried out in several major laboratories funded centrally (TU Delft level) and available to all research staff:

- The *Else Kooi Laboratory* (EKL; directly funded by the Faculty) a cleanroom infrastructure for ME's microsystem research;
- ME's radar laboratory;
- Several RF measurement labs, called the Earl McCune XG Labs;
- To support the HWB theme, an ML-1 bio-measurement lab (Bio lab) will be established in 2024;
- A Cryolab.

The chairs of the different ME sections form the department's Management Team, which is led by the department head, who is supported by the department manager. The management is supported by three internal committees: the Communication Committee, the Education Committee, and the Research Committee.

### 3.3.3 Department of Quantum & Computer Engineering (QCE)

This young Department QCE gradually evolved over the past six years and currently consists of three, partly overlapping research sections:

- Computer Engineering;
- Quantum Circuit, Architectures and Technology;
- Network Architectures and Services.

QCE also manages several experimental facilities, including an advanced facility for the quantum-related research. The QCE department is headed by the management team (MT) which consists of five members: the department head, three section leaders and the department manager (also leader of the Support section). The department head is responsible for the department's daily management and representation, is accountable to the Faculty board and maintains contacts with external stakeholders. QCE has several portfolio coordinators and dedicated committees, such as an education coordinator, a communication coordinator, and a funding committee.

# 4. Findings and recommendations

## 4.1 Faculty EEMCS

*4.1.1 General observations and comments*
The committee observed several topics that should be addressed at Faculty level rather than at the department level. In this section more generic or interdepartmental issues will be described.

*1. Quality Self-Assessment Report*
The EE Self-Assessment Report described the activities of the three departments over the last six years. For instance, the fact that certain policies, such as the TU Delft Code of Conduct and the TU Delft policies and activities on integrity, had been promoted. However, whether such policies have been implemented or have resulted in improved practices was not presented nor was any evidence from monitoring provided. In addition, critical self-reflections on what goes well and what needs improvement were often missing. Finally, there were large differences among the presentations of the three departments.
See recommendations in section 4.1.2, Nr 1 A and B.

*2. Collaborations across EE departments*
The committee observed that the departments mostly operate independently from each other. Any substantiation of cross-departmental cooperations was unclear from the Self Assessment Report and there were no metrics shown like joint publications or joint funded programs to stimulate and monitor this. By extension, this lack of cooperation also exists towards the other three departments of the EEMCS Faculty. The committee also noticed that exchange of best practices or the joint use of experimental facilities was uncommon throughout the three departments. The rather limited research cooperation with other departments and Faculties may also have resulted in less opportunities for participation in larger research initiatives (and the associated funding).
See recommendations in section 4.1.2, Nr 2 A-E.

*3. PhD supervision and monitoring*
The committee was shocked by the observation that since the last evaluation in 2017, no progress has been made regarding the shortening of the PhD project duration, nor improving the high non-completion rates of PhD projects. An additionally provided survey among PhD candidates showed that a large proportion of candidates were unsatisfied about their supervisors and contact with them was generally infrequent. Very surprising was the (low) ambition stated in the Self-assessment report to aim at 70% graduations within five years, while PhD project funding lasts only four years. From the director of the Graduate School the committee learned that (1) he could do nothing else than try to convince that supervisors should take their task (to target a PhD defence within 4 years) more seriously, and (2) that he missed a clear sense of urgency among staff to do that.

The committee concluded that this issue should get the highest priority and that Faculty-wide radical and creative measures are highly needed.
See recommendations in section 4.1.2, Nr 3 A-E.

*4. Publication strategy*
Although the departments mentioned in their self-assessment report that citations are key indicators for research quality, during the site visit the committee encountered scepticism among the Faculty members and their leadership about the meaningfulness of the citation indicators, neither was there any suggestion for better quality metrics to be used for quality and impact assessment and monitoring. From an additionally provided analysis, the committee noticed that the Field Weighted Citation Impact (FWCI) of the departments is relatively low. Next to that, there appeared to be no

clear publication strategy e.g. aiming at improving EE's scientific reputation and greater worldwide visibility.
See recommendations in section 4.1.2, Nr 4 A and B.

*5. Technicians and research facilities*
The committee has seen very well equipped and state-of-the-art laboratories and met very dedicated and motivated technicians working in these labs. During the interview sessions with all three departments, the committee learned that attracting and retaining qualified technicians is difficult. Also, long-term funding for maintenance and upgrading of research facilities appeared to be a major point of worry, which needs explicit attention in the strategy for the coming years.
See recommendation in section 4.1.2, Nr 5 A.

*Specific aspects*
Since some of the specific aspects the committee evaluated mainly take place at Faculty level, those will not be presented at the department level but in this section. This concerns three of the four specific aspects: Open Science, Academic culture and HR policy. Most of the findings related to PhD Policy and training are described in the sections for each separate department.

*6. Open Science*
The increasing efforts towards making research data publicly available are applauded. QCE has already developed several successful open-source products.
The involvement of societal stakeholders in research strategy has not been an explicit point of evaluation by the committee, but it has appreciated that EE cooperates with many societal entities such as industries, governmental bodies, hospitals, et cetera.
See recommendation in section 4.1.2, Nr 6 A.

*7. Academic culture*
The atmosphere during the visit was very positive and energizing, showcasing good team spirit and support for each other. There are explicitly mentions of multiple social events (e.g. drinks) to bring teams together. While this is positive and very natural in a young team, there is need to evolve towards a more diverse team composition.
The committee has not noticed any issues concerning scientific integrity.
See recommendation in section 4.1.2, Nr 7 A.

*8. HR policy*
The three departments have grown a lot in the past period, mainly due to a large investment from the Dutch government as part of the "Sectorplannen". This has resulted in many new appointments of mainly assistant professors. The Sectorplannen also forced the departments to improve on diversity, since at least 35% of the new hires should be female. Some departments managed to perform better on this aspect by hiring even more females. It was seen positive by the committee that the majority of the departments seemed to be very active in direct head-hunting of females in case an open call did not result in talented female applicants with suitable field-specific expertise. In addition, all new hires got a start-up package (one PhD position) for blue-sky research, which the committee sees as a positive policy. This new policy will be continued in the future. Another national development is to change the tenure track system such that new hires will have a go/no-go decision for a permanent contract within 18 months. Both measures (start-up and early permanent contract) are very much appreciated by the committee and also by the young scientific staff members and by the department heads. It makes it more attractive to come to TU Delft. The courses on supervision that TU Delft offers for new assistant professors were highly appreciated by the new assistant professors.

Although the diversity of staff has been improved quite a lot by investments from the Sectorplannen, the percentage of female staff is still quite low (according to Self-assessment report ESE 11% and ME 20 %). Also, the recruitment of more senior professors is a point of attention to be addressed in strategy for coming years.

Some staff members seem to have too many PhD students to supervise.

The rules regarding promotion to higher ranks (from Assistant Prof. to Associate Prof. and from Associate Prof. to Full Prof.) are not very transparent and clear, at least not to all junior professors. Especially the promotion to full professor was not clear to some of the interviewed assistant professors. Tenure track professors also felt that the promotion to Associate Professor is at the moment a highly internal and unclear process with section heads having perhaps a too high impact and using a too restricted view.

Large projects (grants) were mainly organised through full professors without involving new tenure trackers; the latter felt that it was not transparent for them how to get involved in these projects. See recommendations in section 4.1.2, Nr 8 A-G.

### *4.1.2 General overarching recommendations*

*1. Quality Self-Assessment Report*

A. For better consistency in the future, the committee recommends to coordinate at Faculty level the writing of documents like a Self-Assessment Report.
B. In addition, the strategy plan for the coming period could be more ambitious and better articulated concerning the topics to be addressed or problems to be solved.

*2. Collaboration across EE departments*

A. It is recommended to explore opportunities for cooperation between the departments more intensively, as well as with other departments and Faculties.
B. Through this mechanism to participate in strategic initiatives of a bigger scale, possibly even under the EE-NL platform. This also includes a more strategic impact in the context of for instance the Chips Act and large infrastructure programs.
C. It is also recommended to explore opportunities to collaborate on infrastructure facilities or to create joint facilities.
D. The committee recommends to define and monitor specific metrics to measure the real collaboration across disciplines. Examples could include joint publications, products or joint research grants. Such metrics could facilitate the finding of strengths or weaknesses to be addressed in new strategic plans or used when writing research proposals.
E. It is also recommended to clearly install the ownership of cross-departmental Themes.

*3. PhD supervision and monitoring*

A. The relatively low success rate of PhDs and the very long PhD duration need to be addressed with highest priority. The current situation is unfair towards PhD students who get paid for a 4-year contract but require much longer to obtain the PhD degree.
B. (Financial) incentives should be put in place for both the PhD advisors and the PhD students to finish the PhD within 4 years.
C. For cases where the 4-year target cannot be met, fair policies should be defined at Faculty- or TU Delft-level for limited-term paid contract extension. Such policies should be uniformly communicated among staff, PhD students and Graduate School.
D. Continue to monitor PhD satisfaction and to define sustainable actions to provide high quality supervision.

E. Make a Faculty-wide (including the Graduate School) action plan to improve the quality of supervision and evaluate the progress mid-term the next SEP-evaluation. Define clear ownership of this issue.

*4. Publication strategy*

A. The departments are encouraged to spell out a publication strategy and make sure that it is known to all its members (including PhD students). This approach may help to improve the departments' scores on innovation and impact metrics such as the FWCI.
B. Progress achieved on impact metrics should be monitored at least annually and used strategically.

*5. Technicians and research facilities*

A. Define a 10-year plan for maintenance and hiring technical support staff to ensure state-of-the-art research facilities and sufficient qualified technicians for operational support in the labs.

*6. Open Science*

A. Use the experience of department QCE on open-source products to serve as best practice for the other departments.

*7. Academic Culture*

A. Make a plan to evolve towards a more diverse team composition.

*8. HR policy*

A. Use active invitations of females or other professor groups being targeted for vacancies. These personal invitations can be sent out by the Dean or department Head.
B. Potential candidates could be scouted using a recruiter or by looking around at conferences.
C. Take measures not to overload the staff e.g. by limiting the number of PhD students (for daily supervisors) to a reasonable and manageable amount.
D. Improve transparency of requirements for promotion to associate and full professor, preferably uniform across the entire Faculty. Include quantitative indicators and timelines.
E. It is recommended that the full professors would invite new TTs into their large projects and initiatives - at least it is recommended to be transparent to the TTs how they can contribute and be part of such projects (and benefit from their funding).
F. Elaborate a plan to bring best practices into regular hiring practices and share those practices with other departments.
G. The committee recommends that the department makes a systematic follow-up of the PhD graduates (or PhD alumni) employment (in the form of a simple survey) and constantly follows where they finally end up.

## 4.2 The three research units

### *4.2.1 Department of Electrical Sustainable Energy (ESE)*

Head of the Department: Prof. Peter Palensky
Total FTE research staff (2022): 6.0 Full Prof., 3.2 Assoc. Prof., 16.7 Assist. Prof., 22.1 Researchers, 97.2 PhD candidates.

a. <u>Mission and Strategy</u>

To the view of the committee an ambitious plan was presented covering the entire scope from specific component-level (and even material-level) technologies towards complete system-level research. Here are some specific observations based on the self-assessment report and the interviews during the site visit.

*1. Focus areas*
The department has carefully analysed the areas of their research where to focus and which are seen as most promising for the future in the Digital Energy Transition, covering a relatively wide span of areas (HV, cybersecurity, photovoltaics and energy conversion/storage). The department seems to be successful in the choices made and is performing cutting-edge research in these topics.

While the department mission is clearly sustainability, the chosen approaches are highly focused on technology, neglecting possible needs for human factors in the digital transition. These are gaining more and more attraction in other technical universities in the energy section. See recommendation in section 4.2.1 f Nr 1.

*2. ESE Fellow positions*
The department has made a strategic priority to hire so-called ESE fellows from companies to balance the department age composition. The committee sees this as highly successful and a win-win situation to all stakeholders (students, companies, faculty). However, the current way of selection of ESE fellows seems to be largely based on networking and hiring people that are well known (on a personal level) to the Faculty personnel. This process should be broadened. See recommendation in section 4.2.1 f Nr 2.

*3. Collaboration across Faculties*
The department has made significant and impressive efforts to collaborate across Faculty borders via cross-disciplinary initiatives such as PowerWeb, and after initial struggles this has ended in a true success. The committee is highly impressed that the motivation for collaboration via the PowerWeb institute is substance-driven instead of financial incentives. The institute is cross-Faculty (six Faculties are involved) and even reaches out of TU Delft (Erasmus University Rotterdam). See recommendation in section 4.2.1 f Nr 3.

*Added value from belonging to EEMCS*
The department benefits from the current EEMCS Faculty as they need to use expertise in machine learning, mathematics and computer science.

b. <u>Research Quality including facilities</u>
*4. Research products*
The committee is impressed by the outstanding quality of the research products shown by the department: “world records”, awarded publications (Nature, Joule), prizes, et cetera.

Although citations are also mentioned as key indicators for quality, they do not seem to be considered relevant and the department’s Field Weighted Citation Impact (FWCI) is relatively low. See recommendations in section 4.1.2, Nr 4 A and B.

*5. Facilities*
The department has made substantial investments on the infrastructure throughout the sections based on the earlier evaluation and with the support of different funding streams. Although this has resulted in high-end installations and facilities, a strategic plan for the funding and maintenance of these facilities for the coming 10 years is not clear. See recommendation in section 4.1.2, Nr 5 A.

c. <u>Societal Relevance</u>
*6. PhD employment*
During the site visit individual professors mentioned that their PhD students find easily jobs in the industry after graduation. However, there was no clear indication or systematic follow-up made to evaluate this. See recommendation in section 4.1.2, Nr 8 G.

*7. Economic impact on society*
The energy transition has a clear potential to impact the society and the selected topics will generate new economic value, e.g. in start-ups. In addition to journal publications, the department has made a high number of technical products to be used by the peers and other stakeholders. There is, however, no clear indication how the above is measured and monitored.
See recommendation in section 4.2.1 f Nr 4 and recommendation in section 4.2.1 f Nr 6.

d. Viability
*8. Recruiting*
The department has grown during the past period, including the recruitment of diverse TT faculty clearly matching the topics that were defined. Key actions taken to hire diverse talent, such as head hunting or revising vacancies text, are applauded by the committee, but some of the actions have an *ad hoc* character.
See recommendation in section 4.2.1 f Nr 5.

e. Specific aspects
*9. PhD Policy*
The department has experienced high growth (doubled) including an increase of the number of PhDs, which resulted in some complaints from PhDs around communication, expectations and organization. These were addressed by open sessions with PhD students to define remedial actions. It was not clear, however, what these remedial actions were and how the situation has improved.

The PhD average completion time is still longer than 4 years. The ESE department has defined a department guideline to have the first thesis draft in year 3. This is much more ambitious than the one suggested by the Faculty EEMCS (draft at year 4) and we applaud that.
One proposal to achieve the 4-year deadline for graduation is to link PhDs to the original project outline, where timelines are already presented. This is positive, however, the department has to keep monitoring the depth and quality of the PhD education where defining a research line/topic is relevant.
See recommendation in section 4.2.1 f Nr 7 and recommendations in section 4.1.2, Nr 3 A-E.

f. Recommendations
1. The committee suggests to include emerging human behaviour resulting from the new (digital) technologies and societal trends when relevant in ESE's focus areas.
2. The committee proposes to continue the hiring of ESE fellows, but making open calls for such positions and advertising these positions to all possible stakeholders including small startups.
3. For the next 5-year strategy plan of the department, outreach to companies to join the PowerWeb Institute could broaden the impact even further.
4. The committee recommends to define the target impact and record the achievement in a more concrete manner than is currently done (Table D4 in the Appendix to the Self-Assessment Report).
5. Rather than doing it on an *ad hoc* basis, elaborate a plan to bring best practices into regular hiring practices and share those practices with other departments.
6. The committee recommends that the department makes a systematic follow-up for the PhD graduate employment (in the form of a simple survey) and constantly follows where they finally end up.
7. Tune the PhD approach to the student ambitions and capabilities and make clear agreements from the start on expectations (draft at year 3 versus year 4; freedom to find own research topic, et cetera).

### *4.2.2 Department Microelectronics (ME)*

Head of the Department: Prof. Kofi Makinwa
Total FTE research staff (2022): 14.4 Full Prof., 13.0 Assoc. Prof., 19.5 Assist. Prof., 39.5 Researchers, 149.4 PhD candidates.

a. Mission and Strategy

1. ME has a focus on several sub-disciplines within the field of microelectronics (some of which are relatively narrow niches within the entire EE field), clustered in the themes 1) sensing and communication, 2) health and well-being, and 3) autonomous sensor systems, and has a relatively strong industrial focus for most of these. ME attracts significant amounts of funding (around 15 M€ per year), which in 2018-2022 was predominantly 3rd-tier funding with very little 2nd-tier funding. It is good to see that the 2nd-tier funding is again increasing considerably in 2023, thereby establishing a more balanced picture for some of the department's sections.
See recommendation in section 4.2.2 f Nr 1 and 2.

2. Research activities in relation to wireless communication systems (and more generally COMSOC) are relatively poorly developed (even though there are activities at the component level), which is somewhat surprising given the department's focus on the communication theme and the large importance of such systems in the field.
See recommendation in section 4.2.2 f Nr 2.

3. In terms of alignment with the key societally relevant technology areas which TU Delft focuses upon, the department has a strong focus on sensing for health and well-being as well as on digitalization of our society, but much less on areas such as climate change and (embodied) intelligence. A broader diversification of the department's research focus is possible, as microelectronics is an enabling technology serving many application fields.
See recommendation in section 4.2.2 f Nr 2.

b. Research Quality including facilities

4. The department is performing excellent research in the selected areas where it is active, whereby the impact is mostly visible from the industrial recognition and somewhat less from the academic recognition, as suggested by the relatively modest Field-Weighted Citation Impact (FWCI)[1] of less than 1.2 (1.07 in 2022). There does not seem to be a well-articulated publication strategy of which every professor, researcher and PhD student is aware.
See recommendations in section 4.1.2, Nr 4 A and B.

5. The research cooperation with other departments and Faculties still appears to be rather limited and therefore opportunities for participation in larger research initiatives (and the associated funding) may have been missed.
See recommendations in section 4.1.2, Nr 2 A-E.

6. The infrastructure includes excellent and well-equipped labs, especially on microwave and IC measurement systems as well as radar/remote sensing infrastructure. A bio-lab will be established in 2024. There is also a cryolab, but it is somewhat surprising that this facility does not seem to link to the quantum activities in the QCE department, where cryogenic measurements are of key importance. The cleanroom infrastructure for microsystems is somewhat outdated; in 2022 the operations have merged with the Kavli Nanolab of the Faculty of Applied Sciences. It is good to see

[1] It has not been made fully clear to the Evaluation Committee on what basis (with respect to field weighting) the bibliographic benchmarking study (provided later upon demand of the committee) was executed.

that there is a longer-term plan to establish a new joint cleanroom facility on campus, which is also teamed up with the needs of the quantum activities.
See recommendations in section 4.1.2, Nr 2 C.

c. Societal Relevance

7. The number of academically qualified MSc graduates in EE has grown from 80 in 2017 to 135 in 2022. The number of PhD graduates per year is around 20.
The department generates a lot of industrial impact through its research collaborations with companies. It has applied for and obtained quite some patents. There have also been a few spin-off start-ups, though their number is still limited. This is very relevant, since a lot of funding in for example the EU Chips Act is reserved to stimulate start-ups/scale-ups in the area of chip design.
The efforts to promote the ME field to youngsters (to increase the bachelor and master student influx) are applauded, and we encourage strengthening these efforts even further (thereby exploiting the cross-disciplinary themes within the Faculty whenever possible).
See recommendations in section 4.1.2, Nr 2 B.

d. Viability

8. The (long-term) plan for a joint new clean room facility is of key importance for the future viability of the department. There should be continuous efforts to secure these plans, as well as to keep all infrastructure state of the art. The recruitment of qualified technicians to support the research activities was reported to be challenging.
See recommendations in section 4.1.2, Nr 5 A.

e. Specific aspects

*10. PhD Policy*

The number of graduated PhDs (on average 20 per year in the period 2019-2022) is relatively low for a department with about 60 professors (47 FTEs). In addition, very few (less than 10%) of the PhDs finish in 4 years and still a minority (less than 40%) does in 5 years.
See recommendations in section 4.1.2, Nr 3 A-E.

f. Recommendations

1. The research plan could be more ambitious, especially with respect to new emerging research areas and themes outside the current comfort zone. Such new activities could counterbalance the current strong industrial focus of the department and make funding more balanced between longer-term fundamental and applied contract research. The growth in the number of professors may make such research broadening feasible. Applications for funding schemes such as EU ERC, NWO VENI/VIDI/VICI, etc. should be encouraged and facilitated.
2. To make this happen, the team of professors should engage in a process of reflection and discussion on the identification of appropriate new research themes and topics, thereby taking into account that areas such as wireless communication systems are presently somewhat missing, as well as considering the opportunities associated with the TU Delft priority themes (like artificial intelligence and climate change). This broadening approach may also help to enhance the Field-Weighted Citation Impact (FWCI). It is noteworthy that the ME department considers citations to be a relevant indicator of research quality, but does not monitor the FWCI.

### *4.2.3 Department Quantum & Computer Engineering (QCE)*

Head of the Department: Prof. Rob Kooij
Total FTE research staff (2022): 2.7 Full Prof., 5.6 Assoc. Prof., 4.9 Assist. Prof., 4.0 Researchers, 43.9 PhD candidates.

a. Mission and Strategy

1. The approach of the QCE department is to cover disruptive computing (e.g., quantum, neuromorphic, computation-in-memory) across the entire stack from applications down to the technology and device level. This application-driven “full stack” approach is rather unique worldwide. The department consists of three sections (CE, QCAT, NAS) to achieve this. QCE focuses on two specific application themes, namely Health/Well-being and Safety/Security. In this approach QCE is successful and managed to double in size in the past period. The NAS section is currently not represented in the QCE name.

2. Inter-department collaboration (with ME and ESE) is very limited, both in joint projects and in sharing infrastructure, which in turn may limit the overall long-term impact of the research. In the current department structure, there is a gap in compiler expertise (which is a crucial component in the “full stack” approach). In addition, only two application themes are in scope at the moment, whereas the developed concepts and technologies also hold promise to be (re-)used in other application domains/themes.
See recommendations in section 4.1.2, Nr 2 A-E and in section 4.2.3 f Nr 1-5.

b. Research Quality including facilities

3. The QCE scope is diverse and broad, which could pose a risk should the different subdisciplines fall below critical mass in the future (e.g., due to retirements).
It is mentioned that new staff finds it challenging to embed well within both the department and QuTech at the same time. The current facilities are very good.
See recommendation in section 4.1.2, Nr 8 F.

4. A publication strategy is said to be present, albeit the said strategy seems not to be known at all levels in the organization. The targeted conferences and scientific journals are top-ranked in the field.The QCE department is not very familiar with metrics such as the Field-Weighted Citation Impact (FWCI). A clear, accepted, and communicated publication strategy and monitoring of innovation and impact is lacking.
See recommendations in section 4.1.2, Nr 4 A and B.

5. The broad range of activities also requires QCE to continuously work on additional funding to keep the infrastructure state-of-the-art. In addition, there seems to be potential for collaborating with the ME department on joint facilities and infrastructure, such as the cryolab.
See recommendations in section 4.1.2, Nr 2 C and Nr 5 A.

c. Societal Relevance

6. The committee appreciates that QCE already has provided several well-known open-source products, such as the OpenQL tool. QCE is application-driven and focuses on relevant societal topics, such as health and safety. In addition, the staff is very active in exposing their products in tutorials. The impact of the open-source products, however, is not quantified. In addition, the concepts and technologies could also be applicable in other applications domains.
See recommendations in section 4.2.3, Nr 6 and 7.

d. Viability

7. The current funding is very dependent on a small number of large industrial parties, and Quantum plays an important role in the current funding. There is a good culture at the department regarding working together and helping each other with writing individual grants. There seems, however, to be no strategic way of working to connect (in collaboration with ME/ESE) to national and European semiconductor initiatives such as the Chips Act (Pilot lines and NL competence centre) and Dutch growth fund opportunities. In addition, there has been almost no 2$^{nd}$-tier funding (e.g. NWO) in the past years. In this way fundamental research is limited, which could make QCE less attractive in the

future for industrial partners as well. Another observation is that the funding seems to rely a lot on Quantum-related programs, which is a risk.
See recommendation in section 4.2.3, Nr 8.

8. Since the QCE full-stack strategy relies on many sub-disciplines, it could make it more difficult to profile the department and to maintain coherence.
Another point of attention is the challenge to attract new talent, in particular qualified technicians.
See recommendation in section 4.1.2, Nr 5 A.

e. Specific aspects

*9. PhD policy*

The PhD success rate is low and the average PhD duration is far beyond 4 year and did not improve with respect to the previous evaluation. In addition, the recent survey among the PhD students pointed out very critical comments regarding supervision and the role of the promotor.

The committee detects no sense-of-urgency among the Faculty members for improving the success rate of PhDs and to address the issues regarding supervision.

It was also observed that some, though not all, supervisors have too many PhD students to be managed decently. This is both an issue for the PhDs as well as for the (junior) scientific staff involved.
See recommendations in section 4.1.2, Nr 3 A-E.

f. Recommendations

1. The missing expertise on compilers could be solved by considering extending QCE with a new dedicated section on compilers for disruptive computing, either by teaming up with CS, or by recruiting new talent.
2. Consider broadening the scope of the application themes to impact and attract stakeholders from more diverse application fields.
3. The Network section (NAS) opens opportunities for collaboration with ESE (smart grids) and ME (wireless communications); such collaborations should be considered and encouraged.
4. The committee considers quantum sensors a promising future research field that would fit well within this department and should therefore be considered.
5. Explore opportunities to collaborate on facilities or to create joint facilities, for example, with ME.
6. The committee suggests to evaluate, quantify and monitor the usage and impact of released open-source products.
7. The committee also encourages the department to further expose their products to a more diverse set of stakeholders outside of the themes the department currently focuses on. This could be combined with broadening the application themes.
8. The committee recommends to consider expanding the funding towards more fundamental research grants such as NWO and ERC. In addition, consider other funding sources by diversifying the application field.

# 5. Answers to additional questions from the Executive Board of TU Delft

## 5.1 How can the Electrical Engineering departments align their research agendas with Europe's research agenda, the Chips Act and the next Framework Programme?

The three EE departments need to join forces towards the outside world in order to strategically operate in funding opportunities in NL and EU. Currently, this is done individually. As a result, the TU Delft EE departments are not well-connected to all national and EU-related research funding opportunities such as the EU Chips Act and Dutch growth fund initiatives.

A precondition for a successful research proposal is the matching of EE expertise, facilities and reputation with the EU demands in its Calls.
By taking good notice of the intentions and close reading of the EU Calls, the EE staff can learn where EU research funding is aiming at. A visit to Brussels agencies like Nether and EU-Research and to some colleague institutions that have more experience than EE in successfully acquiring EU funding will help to get the proper skills for writing good proposals.
If the match between the available EE competences and the EU demands is not optimal, then complementary expertise needs to be acquired or provided by a partner institute elsewhere in Europe.

Recommendations
1. To improve EE's success rate in acquiring EU funding, it is recommended that EE gathers to make a profile of its strongest fields of research and competences, and also identifies where weaker, but necessary competences exist. The strongest fields are the most important for successful acquisition. If the weaker fields are important for acquiring EU funding, then these areas should primarily be boosted by new investments. The question is whether this is feasible within the current Framework Program.
2. Enhance the visibility of the EE research staff and facilities in order to obtain a well-recognized position within Europe.

## 5.2 How can we further empower early and mid-career scientists?

During the site visit the committee learned that junior tenure-track professors have no clear knowledge on how to make promotion to associate or full professor level. Although the university or Faculty-wide criteria for a promotion are the same on paper, they are interpreted or applied differently among sections. In addition, young staff members are dependent on the full professor(s) who leads their section. Overall, the young professors are keen on building their long-term academic career at TU Delft and highly appreciated the current high-level research infrastructure at EE.

Next to this, questions 5.1 and 5.2 are related to each other in a way that they both concern securing the right competences to fit either with societal demands or with challenging scientific questions or both.
If the competence of the staff is high, but the societal demand or scientific challenge of their research topic is low, then their research does not fit to the actual needs and consequently chances to acquire research funding are low. If the societal demand or scientific challenge is high, but the competences of staff to solve the concerning problems are low, then investments are needed to obtain better skills/ knowledge/ facilities. If both staff competences and societal demands/scientific challenges are high, staff could exploit that optimally in their research grant proposals.

Recommendations
1. The committee recommends that the full professors invite new TTs into their large projects and acquisition initiatives.

2. Use observed gaps in required expertise to further empower early and mid-career scientists towards embarking in the right research directions.

# 6. Annexes

## 6.1 Programme Site visit

| Day | Time | Place | Activity | Participants |
|---|---|---|---|---|
| 25-jan-24 | 10:00 - 12:00 | Online | Kick-off meeting | Committee |
| 4-feb-24 | 17:30 | Restaurant | Welcome of committee | Committee<br>TU Delft: Rector Magnificus and Dean |
| 4-feb-24 | 18:30 | Restaurant | Dinner | Committee |
| 4-feb-24 | 20:30 | Restaurant | Preparatory meeting | Committee |
| 4-feb-24 | 21:30 | Hotel | Closure | |
| 5-feb-24 | 08:30 | EEMCS | Preparation of Interviews | Committee |
| 5-feb-24 | 09:00 | EEMCS | Context of Site Visit - Executive Board | RM & Dean<br>Committee |
| 5-feb-24 | 09:30 | EEMCS | ***Interview with RM & Dean*** | Committee<br>RM & Dean |
| 5-feb-24 | 10:00 | EEMCS | ***Interview with ME management*** | Committee and invitees |
| 5-feb-24 | 11:15 | EEMCS | ***Lab Tour ME*** | Committee and invitees |
| 5-feb-24 | 12:30 | EEMCS | **Lunch with PhD students** | Committee and invitees |
| 5-feb-24 | 13:30 | EEMCS | ***Interview with Tenure Trackers*** | Committee and invitees |
| 5-feb-24 | 14:30 | EEMCS | ***Interview with ESE management*** | Committee and invitees |
| 5-feb-24 | 15:45 | EEMCS | ***Lab Tour ESE*** | Committee and invitees |
| 5-feb-24 | 17:00 | EEMCS | Wrap-up | Committee |
| 5-feb-24 | 18:00 | Hotel | Time off | Committee |
| 5-feb-24 | 19:00 | City | Dinner | Committee |
| 5-feb-24 | 21:30 | Hotel | Closure | |
| 6-feb-24 | 08:30 | EEMCS | Preparation of Interviews | Committee |
| 6-feb-24 | 09:00 | EEMCS | ***Interview with EEMCS Graduate School*** | Committee and invitees |
| 6-feb-24 | 10:00 | EEMCS | ***Interview with QCE management*** | Committee and invitees |
| 6-feb-24 | 11:15 | EEMCS | ***Lab Tour QCE*** | Committee and invitees |

| | | | | |
|---|---|---|---|---|
| 6-feb-24 | 12:00 | EEMCS | Wrap-up | Committee |
| 6-feb-24 | 12:30 | EEMCS | Lunch | Committee |
| 6-feb-24 | 13:00 | EEMCS | Optional meeting with department chairs | Committee;<br>Department Chairs |
| 6-feb-24 | 13:30 | EEMCS | Writing | Committee |
| 6-feb-24 | 16:00 – 16:30 | EEMCS | Presentation of first impression | Committee<br>Dean, EE, SD |
| 6-feb-24 | 16:30 – 17:30 | EEMCS | Appointments finishing report<br>Closure | Committee |

## 6.2 Bio-sketches of the Peer Review Committee members

***Prof.dr.ir. Bart Smolders, Eindhoven University of Technology***
Bart Smolders received his M.Sc. and Ph.D. degree in Electrical Engineering from Eindhoven University of Technology (TU/e) in 1989 and 1994, respectively. He worked at NXP (formerly Philips) Semiconductors, responsible for the innovation in the RF business line. Since 2010, he is full-time professor at the TU/e and chairman of the Electromagnetics Group with special interest in antenna systems and applications, such as 6G wireless communications. In particular, he is co-founder of the FNS-6G national growth-fund project. He is also co-founder of the start-up company ANTENNEX. Next to his research activities, he was the dean of the Electrical Engineering department of the TU/e in the period 2016-2023. Currently, he is responsible (ambassador) for the Future Chips initiative at TU/e.

***Prof.dr. Maria Sabrina Greco, University of Pisa***
Maria Sabrina Greco (Fellow IEEE) is with the Dept. of Information Engineering of the University of Pisa, where she is Full Professor since 2017. She's IEEE fellow since Jan. 2011. She was co-recipient of the 2001 and 2012 IEEE Aerospace and Electronic Systems Society's Barry Carlton Awards for Best Paper published on the T-AES, co-recipient of 2019 EURASIP JASP Best Paper Award, co-recipient of the 2019 H Mimno Award for the best paper published on the AE Systems Magazine, recipient of the 2008 Fred Nathanson Young Engineer of the Year award for contributions to signal processing, estimation, and detection theory and of IEEE AESS Board of Governors Exceptional Service Award for "Exemplary Service and Dedication and Professionalism, as EiC of the IEEE AES Magazine".

She has been general-chair, technical program chair and organizing committee member of many international conferences over the last 10 years. She has been also lead-guest editor of many special issues on Radar Signal Processing. She's Editor in Chief of the EURASIP *Journal of Advances in Signal Processing*. She has been member of the IEEE SPS BoG (2015-17), Chair of the IEEE AESS Radar Panel (2015-16), SPS Distinguished Lecturer for the years 2014-2015, AESS Distinguished Lecturer, AESS VP Publications (2018-2020), EiC of the IEEE Aerospace and Electronic Systems Magazine and IEEE SPS Director-at-Large for Region 8 (2021-22). She's now President of AESS (2024-25).

Her general interests are in the areas of statistical signal processing, estimation and detection theory. In particular, her research interests include clutter models, coherent and incoherent detection in non-Gaussian clutter, CFAR techniques, radar waveform diversity, bistatic/mustistatic active and passive radars, cognitive radars and integration of sensing and communications. She co-authored many book chapters and more than 250 journal and conference papers.

***Dr. Artur Podobas, Royal Institute of Technology***
Artur Podobas defended his PhD thesis at KTH Royal Institute of Technology in December 2015. His PhD topic was on task-parallel programming models (e.g., OpenMP, Cilk+, etc.), where he explored the task-based programming model, particularly close to the hardware. After his defense, he spent one year as a post-doc at Denmark's Technical University (DTU), working on the EU COPCAMS project. In 2016, he received the JSPS scholarship for a two year post-doc in the Matsuoka laboratory at the Tokyo Institute of Technology. In 2019, he worked as a researcher on future computer architectures at RIKEN Centre for Computational Science (R-CCS) in Kobe, Japan.

Today, Artur Podobas is an associate professor at KTH Royal Institute of Technology, where he leads a research team that focuses on high-performance reconfigurable-, and neuromorphic architectures. He is the recipient of the Swedish Research Council's starting grant. He has co-authored over 60 peer-reviewed articles and has been a member of several technical program committees. He is also the organizer of the CGRA4HPC workshop series. He is also a co-PI in two currently running EU

projects (ASAP and EXTRA-BRAIN), and he is a member of the Swedish e-Science Research Centre (SERC).

***Prof.dr.ir G.E. (Georges) Gielen, KU Leuven***
Georges Gielen received the MSc and PhD degrees in Electrical Engineering from the Katholieke Universiteit Leuven (KU Leuven), Belgium, in 1986 and 1990, respectively. Currently, he is Full Professor in the MICAS research division at the Department of Electrical Engineering (ESAT) at KU Leuven. From August 2013 until July 2017 he served as Vice-Rector for the Group of Sciences, Engineering and Technology. He was visiting professor at UC Berkeley and Stanford University. Since 2020 he is Chair of the Department of Electrical Engineering (ESAT) at KU Leuven.
His research interests are in the design of analog and mixed-signal integrated circuits, and especially in analog and mixed-signal CAD tools and design automation, including modeling, simulation, optimization and synthesis as well as testing. He is a frequently invited speaker/lecturer and coordinator/partner of several (industrial) research projects in this area, including an ERC Advanced Grant. He has (co-)authored 10 books and more than 700 publications in edited books, international journals and conference proceedings. He is a 1997 Laureate of the Belgian Royal Academy of Sciences, Literature and Arts in the discipline of Engineering. He is Fellow of the IEEE since 2002, and received the IEEE CAS Mac Van Valkenburg award in 2015 and the IEEE CAS Charles Desoer award in 2020, as well as the EDAA Achievement Award in 2021. He is an elected member of the Royal Flemish Academy of Belgium in the class of Technical Sciences, and of the Academia Europaea.

***Prof.dr.ir. R. (Roel) Baets, Ghent University***
Roel Baets is an emeritus full professor at Ghent University (UGent; October 2023) and a former group leader at IMEC, both in Belgium. He received an MSc degree in Electrical Engineering from UGent in 1980 and a second MSc degree from Stanford University in 1981. He received a PhD degree from UGent in 1984. From 1984 till 1989 he held a postdoctoral position at IMEC. Since 1989 he has been a professor in the Faculty of Engineering and Architecture of UGent where he founded the Photonics Research Group, which he has chaired until October 2022. From 1990 till 1994 he has also been a part-time professor at Delft University of Technology and from 2004 till 2008 at Eindhoven University of Technology, both in The Netherlands.

Roel Baets has mainly worked in the field of integrated photonics (PICs). He has made contributions to research on photonic integrated circuits, both in silicon photonics and in III-V semiconductors, including their heterogeneous integration. In 2006 he founded ePIXfab, the globally first Multi-Project-Wafer service for silicon photonics. Since then ePIXfab has evolved to become the European Silicon Photonics Alliance. He has also been director of the multidisciplinary Center for Nano- and Biophotonics (NB Photonics) at UGent, founded in 2010.

Roel Baets has been a personal grantee of the European Research Council and a Methusalem grantee of the Flemish government. He is a Fellow of the IEEE, of the European Optical Society (EOS) and of Optica. He has been a member of the Board of Governors of IEEE Photonics Society and of the Board of Directors of Optica. He is a member of the Royal Flemish Academy of Belgium for Sciences and the Arts. He has been a recipient of the 2011 MOC award, of the 2018 PIC-International Lifetime Achievement Award, of the 2020 OSA-IEEE John Tyndall award and of the 2023 IEEE Photonics Award. As an emeritus professor Roel Baets continues a variety of advisory roles within the Photonics Research Group, within ePIXfab and in the integrated photonics community at large.

***Prof.dr. Hele Savin, Aalto University***
Hele Savin works as full professor of Micro and Nanoelectronics at Aalto University Finland (School of Electrical Engineering) and as Tandem Academy Industry Professor at silicon wafer supplier Okmetic Inc. Her primary research interests focus on microelectronics, photovoltaics and nanotechnology. She obtained her D.Sc. (Tech.) degree in semiconductor technology from Helsinki University of

Technology, Finland in 2005. During her scientific career, she has been visiting scientist in University of Berkeley California (2002-2003), Fraunhofer Institute of Solar Energy Systems (2009-2010), Massachusetts Institute of Technology (2013) and University of New South Wales (2019). Examples of personal research grants she has received include Alexander von Humboldt, European Researcher Excellence Grant and ERC Starting Grant. Her research awards include Young Scientist by World Economic Forum, World Cultural Council WCC Special Recognition in Science and Knight, First Class, of the Order of the White Rose of Finland. In addition to academic achievements, many of her research results have been commercialized through patents and intense collaboration with industry including founding of successful start-up company ElFys Inc. She belongs to international scientific committees in various conference organizations and regularly evaluates academic research projects and academic positions both nationally and internationally. Recently, she has evaluated research infrastructures as well as mathematics, ICT and technology research for Norwegian Higher Education Institutes. At her home university she is a member of the university level tenure track committee as well as school level PhD committee.

***Clara Otero MSc, NXP***
Ms Clara Otero Perez has more than 20 years of experience in the automotive semiconductor industry. As Senior Director of System Solutions, she is a leading driver behind NXP's company-wide system strategy envisioning, defining and releasing a broad set of automotive system solutions and innovations, including latest technologies on Electrification (Battery Management Systems), Autonomous Driving (Radar) and Connectivity (Ultrawide Band).

Shortly after she graduated with a Master of Science in Physics by the University of Santiago de Compostela in 1998, she started working at Philips Research in the Netherlands as a research scientist in the fields of Computer Architecture specializing in resource scheduling, streaming architectures and real-time systems.

In 2006 she moved to NXP Research and expanded her scope to automotive networks and secure connected systems. Her career at NXP continued in various leading R&D roles, starting as department manager of the *SoC architectures and infrastructures* (2008-2010) to Director of Innovation at the *Advanced Application Lab* (2010-2018) driving innovation in the areas of IoT, connected, electric, autonomous vehicles and cooperative mobility.

During her extensive R&D trajectory, she has participated and led European subsidy projects and initiated/sponsored multiple partnership with leading University and Research Institutes. She was part of the industry advisory board of government funded university programs. She has been member of the Advisory Board Member for Eindhoven Engine (2019 - ) and of the Dutch Node Strategy Committee EIT Digital (2016 – 2018).

Clara held leadership roles for the Eindhoven Site Management and for the NXP's European Women's Leadership team.

***Tariq Bontekoe MSc, University of Groningen***
Since December 2022, Tariq is a PhD student at the University of Groningen. He is affiliated with the Bernoulli Institute in the Computer Science Department, particularly in the Information Systems group. He is specializing in applied cryptography, with a specific focus on public verifiability of privacy-preserving computations on distributed data. Before this, he was employed as a scientist at TNO (2020-2022) within the Applied Cryptography & Quantum Algorithms department (formerly part of Cyber Security & Robustness) within the ICT Unit, where he mainly worked on privacy-enhancing technologies and the applications of quantum computing.
After his BSc in Industrial & Applied Mathematics at the University of Twente (UT), he obtained a double MSc degree in Applied Mathematics (Discrete Mathematics & Mathematical Programming)

and Computer Science (4TU.CyberSecurity). During his time there, he has been actively engaged in various academic and professional activities, such as serving on the committee for programming education in Applied Mathematics and being a member of the steering committee for a new Electronic Learning Environment at the UT. He also held a board position (2015-2016) as Chairman and Officer of Educational Affairs at W.S.G. Abacus, the UT study association for Applied Mathematics.

***Chris Mollema PhD FRES***

Since July 2022 Chris retired as senior advisor research at the central staff department 'Research & Impact Strategy' at Radboud University, Nijmegen (2006-2022). He had a similar position at the central staff department 'Research Strategy' at Wageningen University & Research (1998-2006). In these jobs he was largely involved in research quality, evaluations of research units and future planning of research. He served at several international research evaluation committees as secretary or member. He was member of the advice committee for the new version of the national research evaluation protocol (SEP2015-2021) and held an invited lecture during the international seminar 'Research Evaluation & Assessing Research Quality' at the European Academy, Berlin 2016.

After his MSc (Biology) at Utrecht University and PhD at Leiden University he became senior researcher 'Breeding for Resistance to Insect Pests' at Wageningen University & Research (1987-1998). In this period he established and led a team working on sustainable resistance to herbivorous insects in several horticultural crops. He acquired a personal grant from the EU in 1994, which he used to work as visiting professor at Warwick University, UK. He is an elected Fellow of the Royal Entomological Society (UK) and a previous editor of the international journal *Euphytica* (1988-1998). From 2001-2005 he was member of the Committee on Agriculture, Food and Biotechnology of the European Science Foundation's program COST to select and supervise collaborative research programs. He was also member of several committees of the Dutch Ministry of Agriculture (*e.g*. on Genebanks) and many selection and supervisory committees of PhD projects financed by the national research funding agency NWO.

## 6.3 Quantitative data on the research unit's composition and funding

Composition of staff in numbers and FTE per year

| | SEP staff categories | 2017 | | 2018 | | 2019 | | 2020 | | 2021 | | 2022 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Department** | **Count all researchers** | **#** | **FTE** | **#** | **FTE** | **#** | **FTE** | **#** | **FTE** | **#** | **FTE** | **#** | **FTE** |
| ESE | Assistant professor | 7,3 | 7,3 | 8,7 | 8,7 | 11,6 | 11,6 | 16,3 | 16,3 | 18,1 | 18,1 | 16,7 | 16,7 |
| ESE | Associate professor | 2,9 | 2,9 | 3,8 | 3,8 | 4,0 | 4,0 | 4,0 | 4,0 | 4,8 | 4,8 | 3,8 | 3,2 |
| ESE | Full professor | 9,8 | 6,0 | 10,0 | 6,0 | 9,7 | 5,7 | 9,0 | 5,0 | 9,5 | 5,5 | 10,1 | 6,0 |
| ESE | Researchers | 36,7 | 27,1 | 32,8 | 26,1 | 30,6 | 26,0 | 25,4 | 22,7 | 21,5 | 18,7 | 26,9 | 22,1 |
| *ESE* | *(Postdoc researchers)* | *13,3* | *13,0* | *12,1* | *12,1* | *14,6* | *14,6* | *11,4* | *11,4* | *10,5* | *10,5* | *11,4* | *11,3* |
| ESE | PhD candidates | 69,5 | | 70,6 | | 66,4 | | 68,5 | | 74,8 | | 97,2 | |
| **Total Research Staff ESE** | | **56,6** | **43,2** | **55,2** | **44,6** | **55,8** | **47,3** | **54,7** | **48,0** | **53,8** | **47,0** | **57,4** | **48,0** |
| ESE | Support staff (research) | 9,0 | 7,8 | 9,0 | 7,9 | 9,0 | 7,9 | 10,8 | 9,7 | 11,6 | 10,5 | 11,1 | 10,4 |
| ESE | Visiting Fellows | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 1,5 | 0,3 |
| **Total Staff ESE** | | **65,6** | **51,1** | **64,2** | **52,5** | **64,8** | **55,2** | **65,5** | **57,7** | **65,4** | **57,5** | **70,0** | **58,8** |
| ME | Assistant professor | 10,7 | 9,3 | 9,5 | 9,3 | 11,8 | 11,0 | 15,8 | 15,0 | 17,3 | 16,6 | 20,2 | 19,5 |
| ME | Associate professor | 16,0 | 13,2 | 15,7 | 12,8 | 14,3 | 12,7 | 13,4 | 11,9 | 14,0 | 12,6 | 14,8 | 13,0 |
| ME | Full professor | 21,3 | 12,3 | 23,8 | 13,5 | 25,4 | 14,0 | 27,4 | 14,3 | 26,2 | 14,2 | 26,0 | 14,4 |
| ME | Researchers | 87,9 | 62,8 | 85,6 | 55,9 | 79,3 | 51,1 | 77,7 | 55,0 | 62,4 | 45,1 | 56,4 | 39,5 |
| ME | *(Postdoc researchers)* | *26,2* | *24,7* | *20,2* | *18,3* | *18,2* | *16,2* | *21,8* | *18,7* | *20,2* | *19,3* | *16,5* | *15,8* |
| ME | PhD candidates | 128,2 | | 140,0 | | 140,5 | | 144,8 | | 147,6 | | 149,4 | |
| **Total Research Staff ME** | | **136,0** | **97,6** | **134,5** | **91,6** | **130,8** | **88,8** | **134,3** | **96,2** | **119,9** | **88,5** | **117,3** | **86,4** |
| ME | Support staff (research) | 18,9 | 17,8 | 17,9 | 16,6 | 16,0 | 14,6 | 14,5 | 13,4 | 16,8 | 15,7 | 16,2 | 15,0 |
| ME | Visiting Fellows | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 |
| **Total Staff ME** | | **154,9** | **115,5** | **152,4** | **108,2** | **146,8** | **103,3** | **148,8** | **109,6** | **136,8** | **104,2** | **133,6** | **101,4** |
| QCE | Assistant professor | 2,0 | 1,7 | 4,9 | 4,3 | 4,9 | 4,3 | 4,9 | 4,3 | 5,0 | 4,4 | 5,5 | 4,9 |
| QCE | Associate professor | 6,5 | 4,9 | 6,0 | 4,4 | 6,0 | 4,4 | 6,8 | 5,2 | 7,4 | 5,48 | 8,0 | 5,6 |
| QCE | Full professor | 6,0 | 3,6 | 6,0 | 3,6 | 6,0 | 3,6 | 5,3 | 3,5 | 4,0 | 2,6 | 4,3 | 2,7 |
| QCE | Researchers | 9,6 | 8,7 | 9,0 | 8,4 | 9,2 | 8,4 | 9,4 | 9,2 | 5,5 | 5,5 | 4,0 | 4,0 |
| QCE | *(Postdoc researchers)* | *6,3* | *6,3* | *3,8* | *3,8* | *3,4* | *3,2* | *4,0* | *3,8* | *5,4* | *5,4* | *3,0* | *3,0* |
| QCE | PhD candidates | 43,7 | | 50,6 | | 49,4 | | 47,5 | | 46,1 | | 43,9 | |
| **Total Research Staff QCE** | | **24,1** | **18,9** | **25,9** | **20,7** | **26,1** | **20,7** | **26,4** | **22,2** | **21,9** | **18,0** | **21,7** | **17,1** |
| QCE | Support staff (research) | 0,3 | 0,3 | 0,7 | 0,7 | 0,6 | 0,6 | 1,4 | 1,4 | 2,0 | 2,0 | 2,0 | 2,0 |
| QCE | Visiting Fellows | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 |
| **Total Staff QCE** | | **24,3** | **19,1** | **26,6** | **21,4** | **26,7** | **21,3** | **27,8** | **23,6** | **23,9** | **20,0** | **23,7** | **19,1** |

Funding sources and expenditures in K€ and percentages per year

| | **2016** | | **2017** | | **2018** | | **2019** | | **2020** | | **2021** | | **2022** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***ESE Funding*** | € | % | € | % | € | % | € | % | € | % | € | % | € | % |
| Direct Funding (1) | 2.299 | 35% | 2.482 | 36% | 2.563 | 31% | 2.979 | 31% | 3.145 | 42% | 3.937 | 42% | 4.394 | 37% |
| Research Funding (2) | 645 | 10% | 766 | 11% | 1.064 | 13% | 1.648 | 17% | 1.538 | 21% | 1.252 | 13% | 1.821 | 15% |
| Contract Funding (3) | 3.982 | 60% | 3.746 | 54% | 5.296 | 64% | 4.609 | 48% | 2.770 | 37% | 4.056 | 44% | 5.776 | 48% |
| Other | -287 | -4% | -25 | 0% | -677 | -8% | 401 | 4% | -35 | 0% | 31 | 0% | 5 | 0% |
| **Total Funding** | **6.639** | **100%** | **6.969** | **100%** | **8.247** | **100%** | **9.636** | **100%** | **7.419** | **100%** | **9.275** | **100%** | **11.996** | **100%** |
| ***ESE Expenditure*** | | | | | | | | | | | | | | |
| Personnel Costs | 3.544 | 54% | 4.657 | 70% | 5.156 | 62% | 5.795 | 71% | 6.075 | 77% | 6.863 | 70% | 8.170 | 69% |
| Other Costs | 3.019 | 46% | 1.962 | 30% | 3.104 | 38% | 2.333 | 29% | 1.782 | 23% | 2.964 | 30% | 3.746 | 31% |
| **Total Expenditure** | **6.562** | **100%** | **6.619** | **100%** | **8.260** | **100%** | **8.128** | **100%** | **7.857** | **100%** | **9.827** | **100%** | **11.917** | **100%** |
| | 76 | | 350 | | -13 | | 1.507 | | -438 | | -552 | | 79 | |
| | **2016** | | **2017** | | **2018** | | **2019** | | **2020** | | **2021** | | **2022** | |
| ***ME Funding*** | € | % | € | % | € | % | € | % | € | % | € | % | € | % |
| Direct Funding (1) | 5.430 | 39% | 5.768 | 44% | 6.055 | 41% | 6.222 | 42% | 6.433 | 41% | 6.930 | 39% | 8.154 | 40% |
| Research Funding (2) | 3.206 | 23% | 3.975 | 30% | 4.395 | 30% | 4.050 | 27% | 3.590 | 23% | 4.287 | 24% | 3.542 | 17% |
| Contract Funding (3) | 9.105 | 66% | 6.938 | 52% | 7.435 | 50% | 6.687 | 45% | 7.980 | 51% | 11.699 | 66% | 12.190 | 60% |
| Other | -3.966 | -29% | -3.436 | -26% | -3.082 | -21% | -2.161 | -15% | -2.444 | -16% | -5.120 | -29% | -3.431 | -17% |
| **Total Funding** | **13.775** | **100%** | **13.245** | **100%** | **14.803** | **100%** | **14.799** | **100%** | **15.560** | **100%** | **17.797** | **100%** | **20.455** | **100%** |
| ***ME Expenditure*** | | | | | | | | | | | | | | |
| Personnel Costs | 7.885 | 59% | 10.385 | 74% | 11.049 | 74% | 11.872 | 74% | 13.156 | 77% | 14.075 | 80% | 14.964 | 74% |
| Other Costs | 5.517 | 41% | 3.615 | 26% | 3.845 | 26% | 4.141 | 26% | 3.887 | 23% | 3.487 | 20% | 5.346 | 26% |
| **Total Expenditure** | **13.403** | **100%** | **14.000** | **100%** | **14.894** | **100%** | **16.013** | **100%** | **17.042** | **100%** | **17.561** | **100%** | **20.310** | **100%** |
| | 373 | | -755 | | -91 | | -1.214 | | -1.482 | | 235 | | 145 | |
| | **2016** | | **2017** | | **2018** | | **2019** | | **2020** | | **2021** | | **2022** | |
| ***QE Funding*** | € | % | € | % | € | % | € | % | € | % | € | % | € | % |
| Direct Funding (1) | 879 | 32% | 1.036 | 50% | 1.095 | 41% | 1.233 | 38% | 2.201 | 50% | 2.421 | 57% | 2.701 | 63% |
| Research Funding (2) | 794 | 29% | 540 | 26% | 596 | 22% | 35 | 1% | 0 | 0% | 0 | 0% | 21 | 0% |
| Contract Funding (3) | 2.099 | 76% | 1.407 | 67% | 1.468 | 55% | 2.143 | 65% | 2.455 | 55% | 2.687 | 63% | 1.556 | 36% |
| Other | -1.018 | -37% | -898 | -43% | -506 | -19% | -135 | -4% | -212 | -5% | -835 | -20% | -6 | 0% |
| **Total Funding** | **2.754** | **100%** | **2.085** | **100%** | **2.653** | **100%** | **3.277** | **100%** | **4.444** | **100%** | **4.272** | **100%** | **4.272** | **100%** |
| ***QE Expenditure*** | | | | | | | | | | | | | | |
| Personnel Costs | 1.720 | 62% | 2.706 | 95% | 3.431 | 101% | 3.599 | 90% | 4.002 | 94% | 3.801 | 92% | 3.901 | 95% |
| Other Costs | 1.041 | 38% | 152 | 5% | -29 | -1% | 394 | 10% | 268 | 6% | 342 | 8% | 198 | 5% |
| **Total Expenditure** | **2.761** | **100%** | **2.858** | **100%** | **3.402** | **100%** | **3.993** | **100%** | **4.270** | **100%** | **4.142** | **100%** | **4.099** | **100%** |
| | -7 | | -773 | | -749 | | -717 | | 174 | | 130 | | 173 | |