1. Background and process

This draft/report has been prepared by Hilde J. Venvik, professor Dept. Chemical Engineering, NTNU, Ivar Bergland, senior innovation advisor, UiO Growth House, UiO, and Halvard Strønen, student of the master program Materials Science for Energy and Nanotechnology, UiO.

based on

Periodic internal evaluation report for the Master program in Renewable Energy Systems (RES) during the period 2019-2023,

as of March 2024, Department of Technology Systems (ITS), prepared by the RES program council, represented by Sabrina Sartori (leader), Ida Elisabeth Rydning/Yvonne Baade (administrative responsible for MSc students at RES), Linda Gammelsæter, Sveinung L. Aga (student representatives), Vebjørn Bakken (external representative), Øivind Kure (representative), Marianne Zeyringer (representative), Mathias Hudoba de Badyn (vice representative)

In addition, the website of the program and the department was consulted to see how the information appears to an external person (potential student). Some students currently in their second semester were interviewed in an informal manner. The survey in "Studentbarometeret" was read.

With respect to **template and submission**, the following information/instructions were received:

«C. Panelets synspunkter organisert etter rapportmalen

Denne delen av rapporten behøver ikke være lang. 2–3 sider er antageligvis nok hvis panelet ikke har mer å si.

Rapporten sendes på epost til saksbehandler, som lagrer rapporten som X-notat i ePhorte på programmets saksnummer. Den er ikke unntatt offentlighet og publiseres (eventuelt ved programmets ønske sammen med egenevalueringen) på programmets nettsider, oppbygging og gjennomføring.»

One meeting (2024-06-07) was held in the external evaluation committee.

Thereafter a draft was circulated and refined via email. We hope the report fulfills the ITS requirements and expectations, and will be useful to further developments.

Trondheim 2024-06-14	Oslo 2024-06-14	Oslo 2024-06-14
Hilde J. Venvik	Ivar Bergland	Halvard Strønen,

2. Conclusion

The conclusions have been summarized in a SWOT analysis followed by a set of recommendations:

SWOT:

STRENGTHS - High interest (#applicants) - Norwegian/EU recruitment base - Systems and renewable focus - Good course portfolio with good balance between focus and breadth - Campus Kjeller location (close to applied energy research) - Dedicated lecturers - Small group learning environment	OPPORTUNITIES - High/increasing demand/interest for the topics, also from abroad - Large relevant labour market nearby
WEAKNESSES - *Campus* Kjeller location (away from main UiO campus and other students) - Withdrawal rate - Only 50-60% of enrolled students have completed this far - Inconsistent and incomplete information available to prospect as well as enrolled students (webpages and other relevant channels) - Gender balance	THREATS - Competition (NMBU/NTNU/HiO/…?) - High cost of the program(?) - Budget cuts in the university sector (?) - Reduced number of students (incl. foreign)

(?) denotes assumptions rather than exact facts

Recommendations

In general, the RES program represents a good way of creating synergy from the UiO-Kjeller (IFE/FFI/…) collaboration, and the training given is to some extent complementary to other programs in Norway. Continuation and further development of the program is therefore recommended as long as the necessary resources are available.

To overcome the problems/weaknesses identified, the following measures are suggested:

1. Improve the information provided on the Department and the Master program.
   a. webpages should be updated with respect to personnel (who are the permanent faculty, how are the groups organized, and what are they experts on?), general information on the program, and explicit information on where and how the courses will be organized.
   b. Information on possible Master topics and supervisors, and courses from other UiO departments with particular relevance to the program should be listed.
   c. stories/profiles on alumni, their competencies, experience, and their current jobs, as well as the research progress/achievements at the department, should be found on the webpages (+ social media)
2. Consider carefully the admission quota, and possibly also the balance between full time and part students to ensure a good learning environment for both groups (who likely do not have exactly the same needs and wishes)

3. Follow up the feedback from students about the courses. From reading the report and interviewing the students, the focus should be on improving the existing courses.
4. Follow up students in progress and delayed. Consider which (individual?) measures that could facilitate their completion. Recording lectures and making them available could be one step, and something that students in general will benefit from.

Measures must however be carefully considered and compromised against cost.

3. Numbers and statistics

Most the necessary information and analysis were given with respect to applicants and completion rate, gender and demographics, quality and competence are given in the internal report, and need not be repeated here.

A main conclusion is that the number of applicants is satisfactory while the number of withdrawals and delayed is somewhat high. Despite a good number of applicants there is, however, a steady decline in the number after year 2. From how the issue of renewable energy is increasing in society and the fact that the program should be better known than the first year, a steady increase may have been expected. Finding out why this is not the case should possibly be a priority, thus looking into the existing student surveys, other feedback, and general trends in comparable programs (e.g., has the applicant number to NTNU Msc “Energi og miljø” also declined during the same period). To which extent this affects the cutoff score should also be monitored and evaluated in view of the number of study places offered, which was increased from 2022 to 2023. It may also be commented that number of part-time students is generally low, and their completion rate does not appear lower than for the rest.

No numbers are presented with respect to cost or resources used. Cost-benefit is thus not analyzed, which would also require some sort of benchmarking or comparison against programs of similar nature (not necessarily similar topic).

4. MSc RES courses

The course portfolio strikes a reasonable balance between breadth/flexibility and focus, i.e., emphasis on energy systems, with some more detail on central renewable technologies and possibility to adapt some specialization/interest. While it is good that the latter is possible, it seems important to maintain a joint, common core curriculum and possibly a profile that stands a bit out relative to the trainings given elsewhere in, e.g., engineering or economics. From the interview it appeared, however, that information about relevant in-depth courses from the other departments at UiO has been missing.

The students have had a saying and seem overall satisfied. It could possibly have been interesting to learn in more detail their experience with the course TEK5380 (project) in terms of both learning environment, learning outcome, and relevance to labor market. Students also want to learn about wind energy, which is reasonable as long as the system perspective is maintained. There is however always desire to expand in all directions, and albeit the relevance of fossil resources to current technologies, one should be careful with encompassing such topics. Integration of circularity principles and challenges is difficult to find.

25% of the students from 2022 quit in their first semester. 25% of the students taking the survey in their second semester said that their academic needs were not met. The academic needs are at the center of any master program. It is recommended that the courses are reviewed in cooperation with the students, so that these numbers go down.

5. Learning environment.

In general, the students appear satisfied with the learning environment, and ITS makes a considerable effort to promote the learning environment. Students see peers as colleagues rather than friends, which likely reflects that they already have a (student) network or even a job. The department/staff do the right things in the sense that they organize start-up/introduction activities (information, lab tours, lunch, etc.), offer reading room space, participation at group meetings, and social events, and – importantly – relatively generous and frequent supervision during the final thesis. There is also a common media channel. It may be commented that not all the students who were informally interviewed by the external committee, confirmed their awareness of the invitation to social happenings like “Holmenkollstafetten” and “sykle til jobben”.

It is therefore difficult to pinpoint measures that can counteract the somewhat low completion rate. The students appear to have already a relatively well-established social life, so emphasis should possibly go towards encouraging their presence at campus and in the learning and working environment. Creating arenas where they wish to participate and can learn from each other or the staff will likely enhance the learning and the quality of the program. Presence at campus is key in this respect, hence it sounds advisable to consider the fraction of part time students accepted in this context.

A straightforward measure to recruit, counteract withdrawals and potentially also improve the learning environment is to improve the external and internal information. In general, it makes limited sense to ascribe communication failure to students’ inability to pick up messages. All important information on the program, the courses, and the social events should be easily accessible.

During this evaluation, the ITS department and RES program webpages were accessed. With respect to the department, the section/group structure was not clear and not all faculty describe their research. For example, a couple of the teachers listed for the courses do not appear in any section or group. No lecturers nor alumni with current jobs are presented at the RES webpages. Given the relatively applied nature of the research, there should be plenty of opportunity to describe its societal impact and possibly also offer involvement by the students. Finally, the informal contact with the student revealed that the day for presentations of master thesis topics and supervisor came very late in the semester, and that only two potential supervisors were present from the RES master program. This could easily be improved.

Our investigations also revealed that despite having promised to do it, some teachers failed to record lectures. Technical reasons for not delivering on this promise are not considered valid in a technology systems program/department. There could be other, more principal, reasons for not offering digital recordings, but then these should be clearly communicated from the start.

6. Relevance to the labor market/satisfaction of alumni

Students who have completed the program are generally positive with respect to the relevance and level of the training given. They mostly find jobs as consultants, which is a large market in the region. The program hence has a role in offering:

1. a system-oriented approach to renewable energy
2. a more applied and business relevant pathway for UiO student beyond their BSc's
3. satisfying the regional and national competence demand
4. facilitating the green transition in Norway

More direct, individual stories of the alumni (interviews or similar) who are currently in jobs would have been informative to the evaluation as well as to future candidates.

Periodic internal evaluation

Master program – Renewable Energy Systems (RES)

period 2019-2023

March 2024

Department of Technology Systems (ITS)

The report has been prepared by the RES program council, represented by:

Sabrina Sartori (leader)

Ida Elisabeth Rydning/Yvonne Baade (administrative responsible for MSc students at RES)

Linda Gammelsæter, Sveinung L. Aga (student representatives)

Vebjørn Bakken (external representative)

Øivind Kure (representative)

Marianne Zeyringer (representative)

Mathias Hudoba de Badyn (vice representative)

Extended Summary

The master program Renewable Energy Systems (RES) (in Norwegian: Fornybare Energisystemer - FENS) aims to educate students with a solid professional background and understanding in energy systems based on renewable energy. This study program is led by the Department of Technology Systems (ITS) and started its offer in 2019. Its foundation was based on previous single courses offered to students of other master programs (mainly at UiO and NTNU) already running for some years in collaboration with adjuncts mainly from the Institute for Energy Technology (IFE). Since 2019 new courses have been developed and the offer modified, as will be discussed in this document. The number of adjuncts at ITS is higher than in other Departments at UiO, with adjuncts responsible/co-responsible of several of the RES courses. This gives the students exposure to real-life projects found at research institutes and companies.

The program is part of a strategic decision from the University of Oslo (UiO) to expand the activity at Campus Kjeller where the Department of Technology Systems is located. Compared to the traditional basic science research conducted at UiO, the research at ITS is often at a higher technology readiness level than most activities at the faculty of Mathematics and Natural Sciences, contributing amongst others with transition to renewable energy, digital inclusion, autonomous systems, space, and security. At Kjeller, ITS is co-located with the Norwegian Defense Research Establishment (FFI) and the Institute for Energy Technology (IFE), which both offer rich opportunities for collaboration. ITS also has a range of interdisciplinary research and educational collaborations that include the UiO Blindern Campus and Oslo Science City, as well as many other national and international institutions and industries.

The RES MSc program lays at the interface between natural sciences and engineering, with ties to social and innovations aspects of technological solutions. It aims to give the students the knowledge needed to understand the complexity of energy systems for stationary and transportation applications. This document provides an internal evaluation of the RES program in the period 2019-2023.

- **Numbers and statistics**

The number of applicants to the RES program is one of the highest at the Faculty of MN at UiO. For this reason, the number of study places was increased from 10 in 2019-2020, to 20 (2021-2022) to 30 (in 2023). While the number of students who accepted the offer and attended the start of their academic year can be satisfactory for 2019-2022, the year 2023 is short compared to the expected target (23 met versus 30 study places). This can be seen in relation to ITS recruiting students from other Departments/Universities since the Department does not offer bachelor studies. Closer partnerships with other bachelor programs at UiO can be seen as a way to improve the number of students recruited to RES.

Of the enrolled active students, 47-67% completed their master thesis, somehow a lower percentage than expected. This must be seen in the context of the fact that some of our students take the master program as part-time (4-years), and/or start working during their studies. A close follow-up of these students in the following months/year will be necessary for a better overview of their progress.

However, the low percentage of completion seems mostly related to the high number of students that withdrew from the program. The reason for this is not clear and will need to be addressed.

A Report from study barometer was not relevant in our case. We instead present in chapter 3 our own survey conducted with past and current RES students, about academic and social learning environment and relevance of the RES study program.

- **Evaluation of Renewable Energy Systems MSc courses**

The RES program is characterized by a strong applied perspective which is attractive to students and stakeholders. The portfolio of subjects in the RES program is expected to increase in the near future, due to newly employed staff and needs of the program. Current courses are developed and updated each year to improve and remain relevant with updated information on the research front. There is a need to redesign the RES program with the implementation of specialization lines. A redesign of the RES program should also consider the rapidly growing demand of knowledge and competences from society at large and stakeholders.

The majority of students are satisfied with the quality of the teaching provided, however some improvement is needed. Students are generally satisfied with the course offer, however explicitly request additional courses, for instance on the subject of wind power.

- **Learning environment**

The students report a good professional and social learning environment. Several measures have been taken to foster a sense of group and cooperation among students of the program. These are larger initiatives organised by the department, smaller events within research groups, activities self-organised through an internal organisation. Measures to communicate information in a written and concise form could help students navigate UiO´s system, especially considering that many of RES students come from external universities. The RES students say in the interview that they are proud to be part of the program. Organizing locally at ITS seminar series of generic competences may benefit the entire master students professional and social environment at ITS.

- **Relevance to working life**

It is clear that RES program appeal to students lies in the more technology oriented, rather than basic science-oriented curriculum. The students perceive the program as relevant and instrumental for a professional job in relevant industries. It is noted that our students are little interested in an academic position, and this is reflected by the type of master thesis mostly chosen (30 ETC) and the type of work of our graduates. Necessary measures to improve the relevance and attractiveness of RES program will be the implementation of targeted steps to make the program more visible to external actors and to prospective students. Also important are targeted measures aimed at students admitted to the study program to connect them early on to relevant workplaces and opportunities.

- **Recruitment**

The RES program clearly needs to strengthen its visibility among students and professional environment. Since many of our past students are employed in energy-relevant companies, they could be a source for extending our outreach to industries and young students. “Advertising events” and materials such as short films, interviews, posters and research groups visit can be good tools to create interest and visibility toward the RES program. Open-door policy and peer-to peer events can

encourage bachelor students to come at ITS and talk to academic staff, younger researchers and students to find out more about what it means to take a MSc degree within the RES program.

1 Background and process – internal evaluation

The Department of Technology Systems (ITS) has currently 13 permanent scientific staff, approximately 35 part-time scientists from the research institutes at Kjeller or from industry, and approximately 20 PhD candidates. At present, the Department of Technology Systems consists of two sections: Section for Energy Systems and Section for Autonomous Systems and Sensor Technologies, which share a significant interdisciplinary overlap. ITS is responsible for and collaborates on several Master´s programs, the ITS-lead Master in Renewable energy systems, the ITS-led Master program in Space systems, the degree program option in Cybernetics and autonomous systems, part of a Master´s degree program in Robotics and intelligent systems at the Department of Informatics (IFI), and in collaboration with IFI on IFI´s Master´s degree program in Information security. ITS is also the host institution for a centre for research-based Innovation called the Centre for Space Sensors and Systems (CENSSS), which participates with NASA in the 2020 Perseverance rover on Mars project. ITS' activities are conducted in close interaction with the existing research and technology communities at Kjeller. Campus Kjeller is located 20 km northeast of Oslo, between the city center and Oslo Airport. It is a 20 minutes commute with public transportation from Oslo city center to the campus.

The internal program evaluation has been carried out by the program council of RES, which is made up of student representatives, the study program secretary, an external representative and four academic staff of ITS (including vice representative). The report is based on an analysis of numbers and statistics taken by our own repository, interviews with students, and internal discussions.

The report is structured as follows: First we present relevant figures and statistics about the RES program (ch. 2), followed by an analysis of the topics relevant to our MSc students (ch. 3). Analysis is then made of how the students experience the learning environment and program affiliation (ch. 4) as well as how relevant the education is in relation to working life (ch. 5) and recruitment to the program (ch. 6). Finally, the report includes Appendix 1-4.

2 Conclusion

In conclusion, the RES MSc program is attractive to students due to a strong applied perspective. The students perceive the program as relevant and instrumental for a professional job in relevant industries. With the latest recruitment of new permanent scientific staff at ITS, the master program will strengthen its offer.

Main weaknesses identified: High rate of withdraw from the program after the first semester; Lack of visibility of the MSc program among professional/industrial actors and prospective students; Lack of clear specialisation study directions.

Outlook of the program: In the rapidly growing sector of renewable energy systems, to stay competitive the RES program will benefit from a redesigned of its offer, in particular with the implementation of specialisation lines. Collaboration and discussion with other Departments at UiO are envisioned.

2 Numbers and statistics (see appendix for additional information)

2.1 Number of applicants and completion rate

Figure 1 and Table 1 give an overview of number of applicants and admission numbers to the MSc program Renewable Energy Systems (RES)/Fornybare Energisystemer (FENS) for 2019-2023.

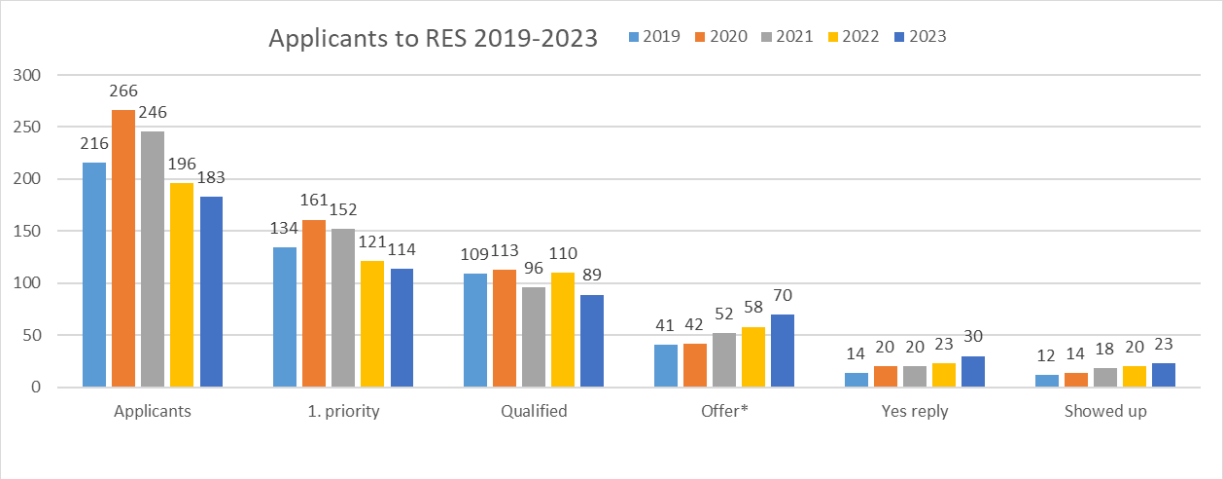


Figure 1. Overview of number of applicants in 2019-2023 for RES.

The trend of Figure 1 and Table 1 shows that the number of applicants is high compared to the available places. The number of qualified applicants appears stable, with minor variations. The number of students at the beginning of the academic year is in line with the number of available study places (Figure1 and Table 1), except for 2023. The available study places for RES have increased during the years as shown in Table 1.

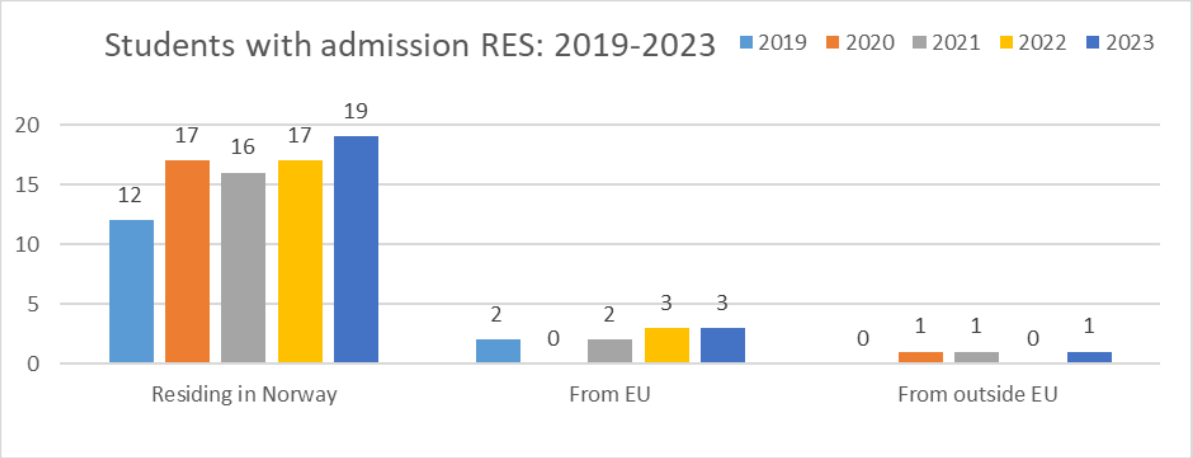
In addition, Table 1 reports the threshold grade average for admission. Due to the increased number of study places to 30 students, in 2023 we decreased the threshold grade average for admission.

Table 1. Overview of number of applicants, 2019-2023, for RES (FENS) from EU and Norway including the threshold grade average for admission.

Year	Opptaks-ramme	Søkere	1.pri	Kval.	Tilbud*	JaSvar	Møtt	Poenggrense
2019	10	216	134	109	41	14	12	3,8
2020	10	266	161	113	42	18	14	3,75
2021	20	246	152	96	52	19	18	3,62
2022	20	196	121	110	58	22	20	3,7
2023	30	183	114	89	70	30	23	2,62

** inkludert evt. Suppleringsopptak*

Most applicants who are admitted to the program, and who meet, are applicants residing in Norway and EU, as shown in Figure 2 below.



F*igure 2. Number of admissions based on residing applicants in Norway, from within EU and outside of the EU.*

Of the students registered in 2019-2023, Figure 3 reports the share of female/male students. The program attracts a majority of male students.

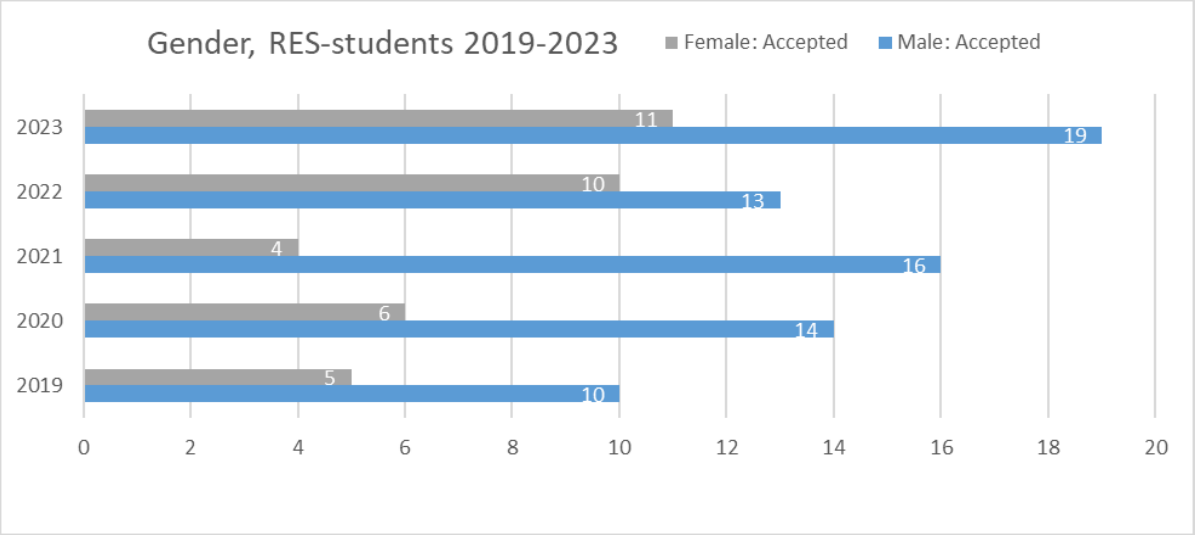


Figure 3. Number of female/male students enrolled/that says yes in the RES program, years 2019-2023.

Completion rate

We will discuss here the number of students who are active and completed their master thesis TEK5930 (30 ETC), TEK5960 (60 ETC). Please also refer to Figure A1.2 in Appendix 1.

Of the 2019 cohort, 8 students completed, 4 withdraw from studies. Of the 2020 cohort, 10 completed, 8 withdraw from studies from first semester; of 2021 cohort, 7 completed, 3 still active, 10 withdrew. Of the 2022 cohort, 15 are active, 7 withdraw from studies. Of the new cohort of 2023, 17 passed exams in the first semester, 5 withdraw from exams, 1 admission was revoked.

The reason behind the withdraw from the program is somewhat unclear and will need to be investigated. Partial feedback reports some students were surprised the Master program was hosted at

Kjeller, some found the program did not meet expectations in the first weeks, or would like to try other master programs. This is an indication that information given about the RES need to be more clear, and that it will be important to foster the feeling of a class to encourage continuous attendance.

Part-time study. The program has a number of students who chose to complete the program as a part-time in combination with their employment (that is completing the master in 4 years instead of 2 years). Some of these students have decided to quit the program. Of the 4 years students registered in 2019, two/third decided to quit, 1 is planned to finish in June 2024. One part-time student registered in 2020 completed the master in June 2023. One part-time student registered in 2021 will submit the thesis in June 2024. One part-time student registered in 2022 is still part of the master program. Finally, one part-time student was registered in 2023. Our assessment is that students choosing to study part-time in our master program are motivated, however finally find it unrealistic to complete the program in addition to their working tasks. We therefore question if the offering of a part-time study should be continued.

All the students who were registered for the master exam TEK5930 (30 ETC) in 2021-2023 attended the exam (Figure 4). There is no failure and the average grade for the period corresponds to the letter B. The figure shows also the grade distribution.

	Totalt		Kvinner		Menn	
Antall kandidater (oppmeldt):	20		5		15	
Antall møtt til eksamen:	20		5		15	
Antall bestått (B):	20		5		15	
Antall stryk (S):	0	0%	0	0%	0	0%
Antall avbrutt (A):	0		0		0	
Gjennomsnittskarakter:	B		C		B	
Antall med legeattest (L):	0		0		0	
Antall trekk før eksamen (T):	0		0		0	

Karakter	Antall	Kvinner	Menn
E	0	0	0
D	4	1	3
C	3	1	2
B	8	3	5
A	5	0	5

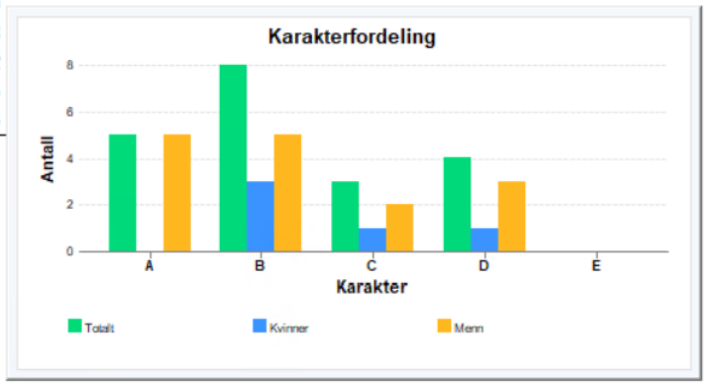


Figure 4 Grades for master thesis TEK5930 (30 ETC), for students that defended in 2021-2023.

The program encourage collaboration with industrial and research partners, with master topics on specific and focused problems. This is reflected by the majority of the students choosing a short master thesis. Of the 6 students registered to take a 60 ETC master thesis, 5 completed (1 in 2021, 1 in 2022, 3 in 2023). Figure 5 shows the grades for master thesis TEK5960 (60 ETC) (of which one female).

	Totalt	
Antall kandidater (oppmeldt):	6	
Antall møtt til eksamen:	5	
Antall bestått (B):	5	
Antall stryk (S):	0	0%
Antall avbrutt (A):	0	
Gjennomsnittskarakter:	C	
Antall med legeattest (L):	0	
Antall trekk før eksamen (T):	0	

Karakter	Antall
E	1
D	0
C	0
B	4
A	0

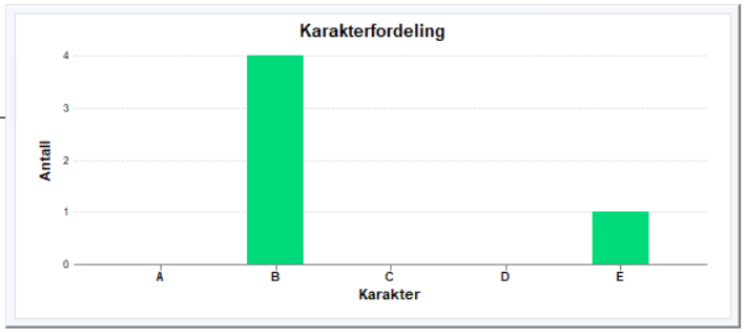


Figure 5 Grades for master thesis TEK5960 (60 ETC).

The completion rate for cohort 2019-2021 is lower than the active students. This again is related to the part-time students who decide to take the program as a four year study. At the same time we register that several of our students start working during their master program and change their plans, delaying the master thesis by few months.

2.2. Study barometer

The study barometer is an annual, national survey under the auspices of NOKUT (National body for quality in education) where all students in the third semester on both bachelor's and master's degree programs (in addition to fifth year students on integrated master studies) are invited to express their opinion about the quality of study programs in Norway. The survey comprises nearly 70 000 thousand students at 58 institutions of higher education. Invitation to participate in the survey is sent by email and SMS. The survey takes place every October, and the results are published in February the next year in the web portal studiebarometeret.no. Unfortunately, the master program RES has too few respondents to display meaningful results. We supply this with own surveys, as presented in Ch. 3.

2.3 Summary

The number of applicants to RES program is one of the highest at the Faculty of MN at UiO. For this reason, the number of study places was increased from 10 in 2019-2020, to 20 (2021-2022) to 30 (in 2023). While the number of students who accepted the offer and attended the start of their academic year can be satisfactory for 2019-2022, the year 2023 is short compared to the expected target 23 met versus 30 study places). This can be seen in relation to ITS recruiting students from other Departments/Universities. Closer partnerships with other bachelor programs at UiO can be seen as a way to improve the number of students recruited to RES.

Of the enrolled active first semester students, 47-67% completed their master thesis, somehow a lower percentage than expected. This must be seen in the context of the fact that some of our students take the master program as part-time (4-years), and/or start working during their studies. A close follow-up

of these students in the following months/year will be necessary for a better overview of their progress. However, the low percentage of completion seems is mostly related to the high number of students that withdrew from the program. The reason for this is not clear and will need to be addressed.

A Report from study barometer was not relevant in our case. We instead present in chapter 3 our own surveys conducted with past and current RES students, about academic and social learning environment and relevance of the RES study program.

3. Evaluation of Renewable Energy Systems MSc courses

The master program consists of 120 credits, of which 40 credits are mandatory (TEK5300, TEK5350, TEK5370, TEK5380). Of the rest of the theoretical syllabus, 30 credits must be specialisation courses chosen from the list below and 20 credits of elective courses which could be chosen from other programs as discussed with the thesis supervisors. Of these up to one course could be chosen at 3000 level. The fourth semester is dedicated to the 30 credits master thesis. In the case of a longer (60 credits) master thesis, the students will be required to complete the program with 40 + 1 specialisation + 1 elective courses.

The students receive information regarding voluntary writing workshops offered centrally at the faculty, where students can practice presentation techniques, writing the master´s thesis and various job search courses. However, it must be noted that these courses are offered far from the Kjeller campus where ITS is located. Therefore, a local offer at the premises of ITS is desirable and under consideration.

Table 2 gives an overview of the course portfolio for the master program at ITS. The majority of our courses are offered both as master and PhD courses. If PhD fellows are enrolled, they will provide additional assignments. Some of our courses are open to students from other programs as single courses (see appendix).

Table 2. List of courses, with course responsible. M = mandatory courses.

Code	Title	Course Responsible
TEK5300 (M)	Renewable Energy: Science and Technology	Sabrina Sartori
TEK5310	*Solar cells*	*Discontinued* *Erik Marstein until 2022*
TEK5320	*Battery Technology*	*Discontinued* *Martin Kirkengen (until 2022)*
TEK5330	Solar Energy Systems	Josefine until 2022 Erik Marstein from 2023
TEK5340	Energy Systems Analysis: Modelling, Methods and Scenarios	Pernille Seljom
TEK5350 (M)	Energy Markets and Regulation	Matin Bagherpour & Marianne Zeyringer
TEK5370 (M)	Grid and smart grid	Josef Noll & Shujun Zhang
TEK5380 (M)	Project in renewable energy	Øystein Ulleberg
TEK5390	Hydrogen Technology	Matylda Guzik & Sabrina Sartori
TEK5410 (5 ETC)	Energy Markets and Regulation - Modelling and Analysis	Marianne Zeyringer
TEK5420 (5 ETC)	Norway's Energy Transitions: Policy Directions and Challenges	Tor Håkon Jackson Inderberg
TEK5430 (5 ETC)	Innovation in Energy Technologies	Sabrina Sartori & external lecturers
TEK5440	Batteries: Technology and Systems	Hanne F. Andersen & Julia Wind

In addition to the list of Table 2, specialization and election courses included in the syllabus by the RES students are given in Table 3 and Table 4.

Table 3. Other TEK-courses taken by RES-students, per cohort/year of admission.

Course code and name	2022	2021	2020	2019
TEK5110 - Building and Monitoring Communication Networks			1	1
TEK5530 - Measurable Security for the Internet of Things	1	1		1
TEK5600 - Visualization of Scientific Data		1		

Table 4. Courses from other Departments, taken by RES-students per cohort/year of admission.

	2022	2021	2020	2019
ECON1210 - Mikroøkonomi 1			1	
ECON4170 - Data science for economists				1
MENA3100 - Characterization of Materials		1		
MENA3201 – Energy Materials		1		
KJM-MENA5110 - Inorganic Structure Chemistry	1			
KJM4310 - Physical Chemistry III - Statistical Thermodynamics for Chemistry	1			
GEO4300 - Geophysical Data Science	1			
STK4900 - Statistical Methods and Applications		2		
FYS-STK4155 - Applied Data Analysis and Machine Learning		1	1	
FYS4231 - Sensors and Measurement Technology			1	
FYS4240 - Data Acquisition and Control		1		
IN5160 - Digital Leadership				1
IN5410 – Energy Informatics	1	3	4	2

The learning outcomes of RES (from webpage) and how the offered courses are supporting them

Learning outcomes

The research and teaching aim to provide you with a solid foundation for developing the use of renewable energy systems in society. The study is suitable for those who wish to work with renewable energy systems.

After completing a master in renewable energy systems, you have achieved:

Knowledge

- You have a good understanding of renewable energy systems, its components and interactions between the components. This includes all renewable energy technologies, different storage technologies, distribution grid, smart grid including sensors. Regulation and control, and both "stand alone" systems and large integrated distribution systems. **(TEK5300; TEK5330; TEK5340; TEK5370; TEK5390; TEK5440)**
- You have a good understanding of national and international regulations and framework conditions for renewable energy systems. This also includes different price models and actions. **(TEK5350; TEK5410; TEK5340)**
- You have profound knowledge in a special field such as solar energy, storage, smart grid. **(TEK5330; TEK5390; TEK5440; TEK5370; TEK5380)**

- You have specialized knowledge in a field of renewable energy systems achieved through the work on a master thesis.

Skills

- You are able to perform an initial design of a renewable energy system. **(TEK5300)**
- You are able to design in detail a subsystem. **(TEK5380; TEK5390)**
- You are able to analyze how changes in functionality in a component will affect the other components of the system. **(TEK5370)**
- You are able to use laboratories and emulators of renewable energy systems to analyze relevant issues. **(TEK5370; TEK5390; TEK5410; TEK5430)**
- You are able to identify, define, present and communicate issues within the subject area. **(TEK5300; TEK5380; TEK5430)**
- You are able to conduct an independent, limited research or development project under supervision and in accordance with current research ethical standards in renewable energy systems. **(TEK5300; TEK5380; TEK5390)**

General competence

- You should be familiar with the subject's development, limitations and opportunities – academic, ethical and social. **(TEK5300; TEK5390; TEK5420; TEK5430)**
- You should be familiar with innovation and innovation processes. **(TEK5430)**
- You should be used to working in interdisciplinary groups. **(TEK5420; TEK5430)**

For individual courses of Table 2 we present a feedback from the teachers in Appendix 2. Here the responsible teachers of the courses were asked to make a self-evaluation based on six questions:

Questions to course teachers (see answers in Appendix 2):

1. Describe the course and how it fits into the RES study program
2. Provide an assessment of the previous knowledge the students need for taking the course
3. Give an assessment of whether the course as it is given today has unintended overlap with other courses at UiO
4. Give an assessment of whether the course has academic relevance in relation to MSc/PhD´s students thesis
5. Give a description of further plans regarding improvements/changes to the course
6. Give an assessment of whether you think the course portfolio of RES study program is missing important elements

We conducted interviews to current master students of RES asking the following:

Questions to MSc students – part 1 (see answers in Appendix 2)

1. How do you think the course offer at MSc level is? Are your academic needs met?
2. Are there particular topic areas that you would like the study program to develop, in the form of additional courses?
3. In general, what do you think about the teaching style of the MSc courses? Is there anything you would like to particularly highlight as positive or negative?
4. Any other comments?

A number of 12 current students (that started the master in 2022) have answered. The survey and collection of answers from the students have been done by a fellow student who completed the master program in June 2023. All students answered during live interviews.

3.1 Summary from course teachers

The RES study program offer is mainly based on competences of ITS staff and adjuncts affiliated to the Energy Systems section. In 2023 new scientific staff has been employed (3 permanent and few adjunct positions), increasing and diversifying skills and competences. From 2019, year of the inauguration of the RES program, the number of its courses has increased, including 5ETC courses. The portfolio of subjects is expected to increase further in 2024/2025, when the new scientific staff will develop their courses.

The background knowledge from students enrolling in the RES program is generally sufficient, though the depth of knowledge varies from student to student. When missing knowledge is present, this is supplied with extra material given by the lecturers.

Courses are developed and updated each year to improve and remain relevant with updated information on the research front. There are no obvious overlaps between courses of RES program, nor with other programs. We note that the RES program, compared to other programs at UiO (which offer more basic science subjects), has an applied perspective. This aspect is attractive to students from other programs who choose single TEK courses as part of their curriculum. The profile of ITS toward energy systems and technology is also the reason for discontinuing the course on "Solar Cells" which was focusing on basic materials for solar cells, therefore considered outside the strategic interest of ITS.

From our cohort of RES students, some include in their curriculum elective courses available in other programs under other Departments (for instance of Physics, Chemistry, Informatics), the most frequent one being IN5410 – Energy Informatics.

A general consensus is the need to redesign the RES program with the implementation of specialization lines after the first common mandatory semester. These specialization lines will need to be identified with internal assessment and will facilitate the students to choose relevant courses for the relative field of interest. A redesign of the RES program should also consider the rapidly growing demand of knowledge and competences from society at large and stakeholders. Collaboration and discussion with other Departments are envisioned.

3.2 Summary the students survey

In relation to course offerings the majority of respondents (9/12) are satisfied, pointing out a good variety of courses. However, some students (3) say they are not satisfied both with the variety of the courses and the quality of lectures. This point will clearly need to be addressed in the further development of RES program. We note that the three newly hired staff members will help increase and strengthen the courses offer.

Extended study options are in demand from the students, for instance about wind and hydropower. Regarding wind power, currently, students receive a background on wind power in TEK5300 (ca. 8 hours) and are interested in specializing in the field. The development of a course on wind power has been discussed for several years at ITS, possibly as a 5 ECTS elective course and in collaboration with IFE. We have been so far unsuccessful. However, from 2024 at UiO there will be a relevant course offered at the Department of Mathematics, which – according to discussions between our two departments – may be available to our students.

The majority of students are satisfied with the quality of the teaching provided. Positive aspects highlighted are the engagement of lecturers, the societal/industrial relevance of the topics, and the active discussions. In relation to improvements, shorter slot of lectures for courses are requested (e.g. 8 hours lectures in a day for a course is pointed out as too long) with consistent breaks for all courses

(e.g. every 45 min), as well as the introduction of interactive elements during the lectures. Assignment without pass/not passed are disliked, such as the many slides not presented but still included in some courses.

Under the point other comments, it is pointed out that in some cases the course should include more background material, not just power point slides, and the information should be structured and easier to find in Canvas.

3.3 Summary

The RES program is characterized by a strong applied perspective which is attractive to students and stakeholders. The portfolio of subjects in the RES program is expected to increase in the near future, due to newly employed staff and needs of the program. Current courses are developed and updated each year to improve and remain relevant with updated information on the research front. There is a need to redesign the RES program with the implementation of specialization lines. A redesign of the RES program should also consider the rapidly growing demand of knowledge and competences from society at large and stakeholders.

The majority of students are satisfied with the quality of the teaching provided, however some improvement is needed. Students are generally satisfied with the course offer, however explicitly request additional courses, for instance on wind power subject.

4 Learning environment (extra information in Appendix 3)

4.1 Start of study

The week prior to the start of the classes, the new RES master´s students meet for few days of preparatory activities (sponsor week, with the first day being compulsory). The format consists of a welcome meeting and general information about the program (including deadlines). These are followed by tours of the building/laboratories, social lunches open to meet teachers and other students from the second year of the master program, and by fun activities in the format of quiz, 3D printing, etc. In the interview with students, it emerged that the sponsor week was useful to get to know the fellow classmates, gain better connections, and receive practical information.

During the first semester, however, it is often necessary to repeat several of the information again, since the students tend to forget some information given during the sponsor week by the administration. As a measure, considering storing important information in the local RES website could be useful.

4.2 General measures

During the first semester the students find a prospective supervisor for their master thesis and fill out the syllabus with the chosen courses. This form is approved by signatures of the supervisors/co-supervisors. Students are offered reading room spaces at ITS, with open seats. Students are typically choosing a short master thesis (with courses amounting to 90 ETC). Based on experience so far, even if invited, the students are not taking part in the group meetings of the chosen supervisor until the last semester (that is until they start working on their master thesis project). Furthermore, many students change the topic of their master thesis and supervisor during the second or third semester, when they form a more precise idea of their interest, and sometime after summer internships at partner institutions (either research institutes such as IFE, and/or at companies).

To facilitate as soon as possible the choice of the topic/supervisor, we organize a day of talks and presentation of master topics from all teachers, including adjuncts. This is generally done in November of the first semester. The supervision given for a master thesis is then focused on the fourth semester, and amounts to approximately two-three hours a week.

We encourage students to take a semester abroad and/or a thesis period abroad. So far only two students have taken this opportunity and reported a high level of satisfaction. Stronger partnership with other programs at Universities abroad can facilitate this opportunity.

The supervisors arrange various activities during the year and include the participation from master students. These vary from group meetings to social gatherings such as table tennis games or cabin tours. Some activities are organized by the entire Department, such as participation in the Holmenkollen relay, or the “Sykle til jobben” action. Students are welcome to such social activities and some take part in them.

In addition, students self-organize themselves through UNIKUM, led by master students. The cohort of both first and second year of students are part of UNIKUM and use a common media channel to exchange news about professional opportunities, announcements, any topics of general interest. UNIKUM has also at its disposal a small sum for organizing social gatherings with food.

How laboratory and assignment work is done varies from subject to subject, and in general involves a task to solve in cooperation. In general, these activities are organized in pairs or groups and have a cohesive effect for those students who do not know each other well (teachers are encouraging

diversity each time). Especially during the first semester, these activities give an extra push to make contact with fellow students early on in the semester.

The first semester consists of three mandatory courses and we understand this as very positive for the creation of a group in each cohort.

4.3 Our perception of the learning environment

Based on the feedback from the survey (Appendix 3), the students stated they have a generally good learning environment. In the interviews the students reported good relationships with fellow classmates and good collaborations when needed. The relation between students is seen mostly as between colleagues rather than friends, and this is confirmed by some of the students not taking part to social activities.

In case of problems during the master program, 9/10 students said they tend to rely on each other, rather than asking help to the teacher or the university organization. The students report to have gained a good social/student network and 9/12 also feel have gained a work-related network. All master students said they were proud to be RES students.

4.4 Proposal for other measures

We recommend to prepare a written collection of practical information aimed at our RES students. This is particularly important since some of our students are coming from other Universities in Norway and abroad and are more vulnerable regarding previous knowledge of the academic environment at UiO. For the same reason they may be outside the social environment at the start of the master program and should be helped as much as possible to get started. The assignment of a master sponsor from the previous cohort for each new student may help navigating UiO´s system and contribute to socialization.

Furthermore, it could be beneficial to organize locally at ITS a seminar series of generic competences, open to all master students of RES, and other master programs at ITS. This may benefit the entire master students social environment at ITS.

It is desirable that each professor/lecturer will offer at least one hour/week of open door, where students are invited to spontaneously meet with the professor/lecturer.

4.5 Summary

The students report a good professional and social learning environment. Several measures have been taken to foster a sense of group and cooperation among students of the program. These are larger initiatives organised by the department, smaller events within research groups, activities self-organised though an internal organisation. Measures to communicate information in a written and concise form could help students navigate UiO´s system, especially considering that many of RES students come from external universities. The RES students say in the interview that they are proud to be part of the program. Organizing locally at ITS a seminar series of generic competences may benefit the entire master students professional and social environment at ITS.

5 Relevance to working life

The RES program has a strong emphasis on fundamental understanding of energy systems and at the same time aims to provide good opportunities for professional competence development. This is done for instance through our courses, where students are facing real-life problems and discussions with relevant industries; through organization of workshops/lectures at ITS with industries; through master thesis relevant for companies and research institutions. We strive to communicate the relevance of RES to working life before choosing a course study (e.g. at various meet – up with prospective students organized at ITS and centrally at UiO), during the education, and in targeted interaction with the labour market.

Our past students are currently employed in the following companies, typically as consultants: NEL; NVE; Climate Change and Sustainability Solutions at Ernst & Young; Norconsult AS; Esgian; Aker Solution. One student started a PhD at ITS after a 60 ETC thesis.

The program council has carried out a survey among former students to collect their views on the study program´s relevance to working life. The survey was sent to all former students who enrolled in 2019-2021 (having completed their thesis by June 2023). Also in this case the survey was conducted by a fellow student, and answers were collected via an online survey (Nettskjema). A number of 12 former students have answered. Many of the feedbacks provide the basis for targeted measures.

Below follows a summary of the feedback (for more details see Appendix 4).

1. To what extent were the job opportunities after completing your studies important in choosing RES as a field of study?

The majority of respondents (92%) say that the possibility of a job after studying influenced their choice to a large or very large extent. This figure shows how, even before starting, the students are aware the RES program provides a good background for job opportunities. In the free text (see Appendix 4) some pointed out the advantages of a diversified knowledge of the energy systems/engineering aspect as very relevant, also as a source of motivation and general knowledge.

2. To what extent did you receive information/guidance about the job market and relevant employers during your course of study?

Almost 42% of the respondents answered that such information was given to a small extent, and 50% to a minor extent. This is worryingly low and will need to be addressed. Centrally at UiO, there are mechanisms to provide career development information, however ITS location (Kjeller) may hinder some of our students from participating in them. These measures must receive greater attention, with facilitation from ITS to allow students to attend such events if they want information about labor market. In the free answers it was noted that seminars/professional days with companies would be desirable, as provided in one of the courses. It is recommended that information/seminars with relevant companies are given in ordinary courses, where this is perceived as natural.

3. How long did you search for jobs after you graduated before being employed?

More than 66% had a job before taking the master exam, which is considered a high number. This is in line with previous considerations, where the profile of our students is different from others at UiO, i.e. interested in working in companies rather than in academic positions. Just over 83% of students had a job within one year after graduation.

4 How important was the specific education you received from the RES program in getting your first job?

There is a clear correlation between the perceived relevance in the RES education and one´s specific first job. 75% say that RES education has had great or very great importance. In the free text answers, it was noted that still the RES study program is less known to the job market, who is interested in more established/well-known field of study. This indicates that efforts should be continued and strengthened in advertising the program both in academic and professional environments.

5. Do the most relevant industries within the job market have knowledge of RES as a study program?

Nearly 60% of the students answer that relevant industries have very little knowledge of the RES program. It is clear that the RES program has a large need for improvement when it comes to communication toward relevant professional sectors.

6. *To what extent do you think the RES program as a whole is relevant to the Norwegian job market? (If foreigner, you can choose to address this based on your own country)*

Here, 75% of the respondents answer that the RES program is very relevant to the job market. Note that none of the students considered the RES program as very little relevant. From the free answers the feedback is that the program offers competences which are in great demand and help our graduate to stand out compared to other applicants.

7. All in all, how satisfied/dissatisfied are you with the academic/professional outcomes of the education within the RES program?

All respondents are satisfied or very satisfied with the academic/professional benefits of the RES program. This is encouraging feedback. In the free answers, this outcome seems related to the technology-oriented curriculum that distinguish our program with others at UiO. Suggestions to extend the offer including specific courses e.g. on wind power, hydropower, have been given often in the previous years by students. We are increasing the portfolio of our courses and are in dialogue with other departments at UiO to include other topics as possible choices as specialisation/elective courses.

Summary

It is clear that RES´s program appeal to students lies in the more technology oriented, rather than basic science-oriented curriculum. The students perceive the program as relevant and instrumental for a professional job in relevant industries. It is noted that our students are little interested in an academic position, and this is reflected by the type of master thesis mostly chosen (30 ETC) and the type of work of our graduates. Necessary measures to improve the relevance and attractiveness of RES program need to be put in place to make the program visible to external actors and to prospective students. Also important are targeted measures aimed at students admitted to the study program in order to connect them early on to relevant workplaces and opportunities.

6 Recruitment

The recruitment has so far involved internal teaching and administrative staff. The RES program has been presented in external podcasts (e.g. organized by industrial clusters), in visits to other Norwegian Universities, with stands, posters and leaflets during career days for bachelor students, and in interviews published in UiO´s and external channels. Additionally, we are active in social media and started with films and interviews of our students. We are currently considering the production of films about the RES program and exploring the possibility for collaboration with media students from OsloMet.

Clearly, from the feedback of the surveys presented in this report, communication to students and professional actors will need to be strengthened.

Some teachers organize visits from bachelor and high school students, however this is done by their own initiative and could be structured as a general offer reaching a larger cohort of students. We are currently considering teachers from ITS visiting students of the last courses of bachelor programs at UiO, delivering a short lecture/presentation of our program.

In addition to the current measures, we highlight the need to organize our webpages clearly, and perhaps organize visits to the research groups at ITS. These visits could be spread over the semester as a way for bachelor students and visitors to learn more about the research done at ITS, stressing an open-door policy. Possibly this will inspire students to take the RES MSc degree and/or connect with possible supervisors. Peer-to-peer discussion between prospective students and the current cohort of students at RES could reduce the barrier for questions about the program. Initiatives targeting industrial actors will be necessary to extend the feasibility of offering master theses with companies, where it is desired. In this case, the activities will need to be well planned so that all parties are aware of their role in the project.

Further, beneficial for recruitment we foresee to increase the visibility of RES through: continuing the initiated discussions with Naturfagsenteret; participation to the Academic-Pedagogical day organised at UiO for teachers; highlight the feedback from students having had a semester abroad as part of the MSc program.

Summary

The RES program clearly needs to strengthen its visibility among students and professional environment. Since many of our past students are employed in energy-relevant companies, they could be a source for extending our outreach to industries and young students. “Advertising events” and materials such as short films, interviews, posters and research groups visit can be good tools to create interest and visibility toward the RES program. Open-door policy and peer-to peer events can encourage bachelor students to come at ITS and talk to academic staff, younger researchers and students to find out more about what it means to take a MSc degree within the RES program.

Appendix 1

Numbers and statistics

Number of applicants and completion rate

Of the total number of applicants, table A1.1 shows whom of these was qualified to apply to master's degree at UiO/Norway and the RES program, included those from outside EU.

Table A1.1. Total number of applicants, including outside EU.

	Residing in Norway (including EU)	**Outside EU**	**In total**
2019	160	95	255
2020	210	224	457
2021	186	162	406
2022	120	140	283
2023	148	151	314

Of the above total number of applicants, Figure A1.1 shows whom of these was qualified to apply to master's degree at UiO/Norway and the RES program, included those from outside EU.

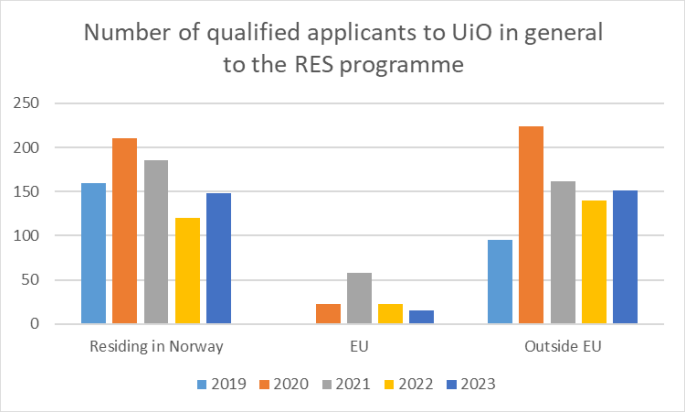


Figure A1.1. Number of qualified applicants to UiO and the RES-program in general, both residing, from EU and outside of EU.

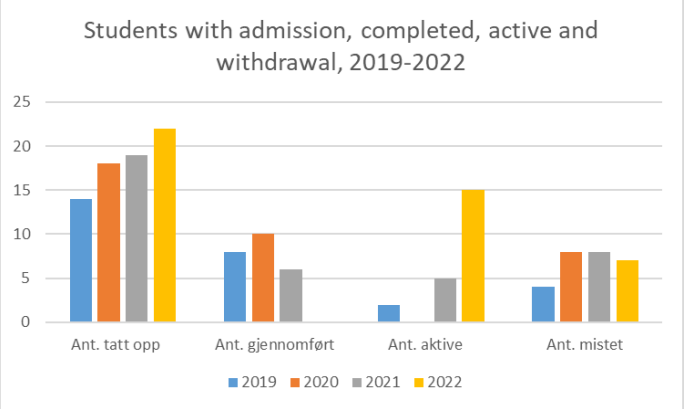


Figure A1.2 Number of students and completion rate for 2019-2022. Students completed from cohort 2021 amount to 7 (missing one in the figure).

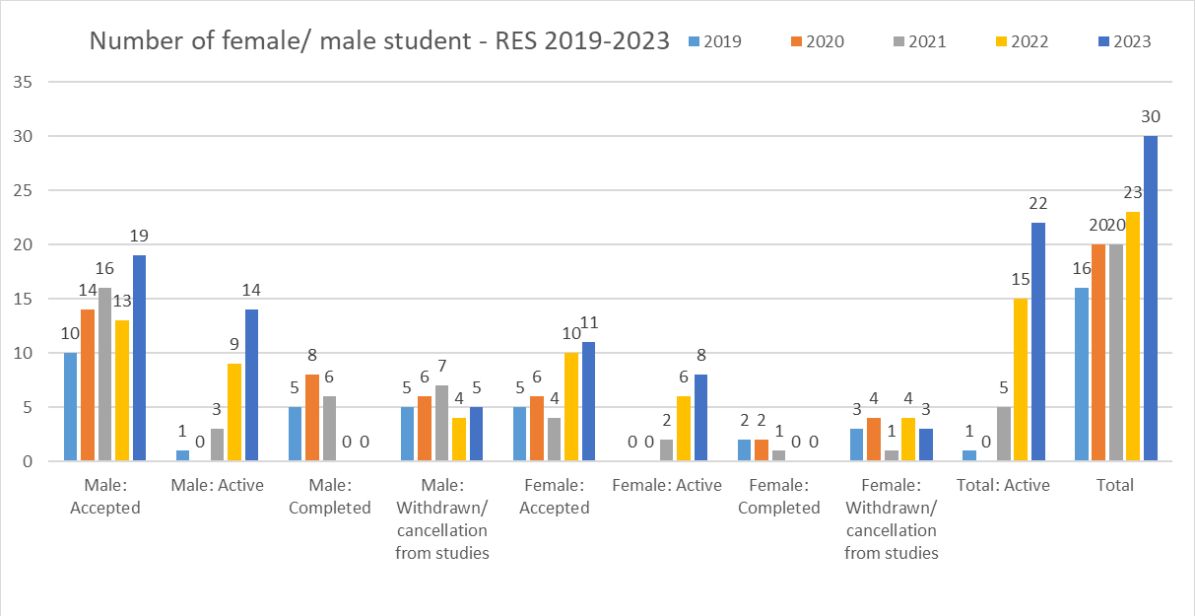


Figure A1.3. Number of female/male students enrolled in the RES program, years 2019-2023.

Applicants to RES are from other departments at UiO, other Universities in Norway and abroad. For a detailed overview see Figure A1.4, for the period 2019-2023).

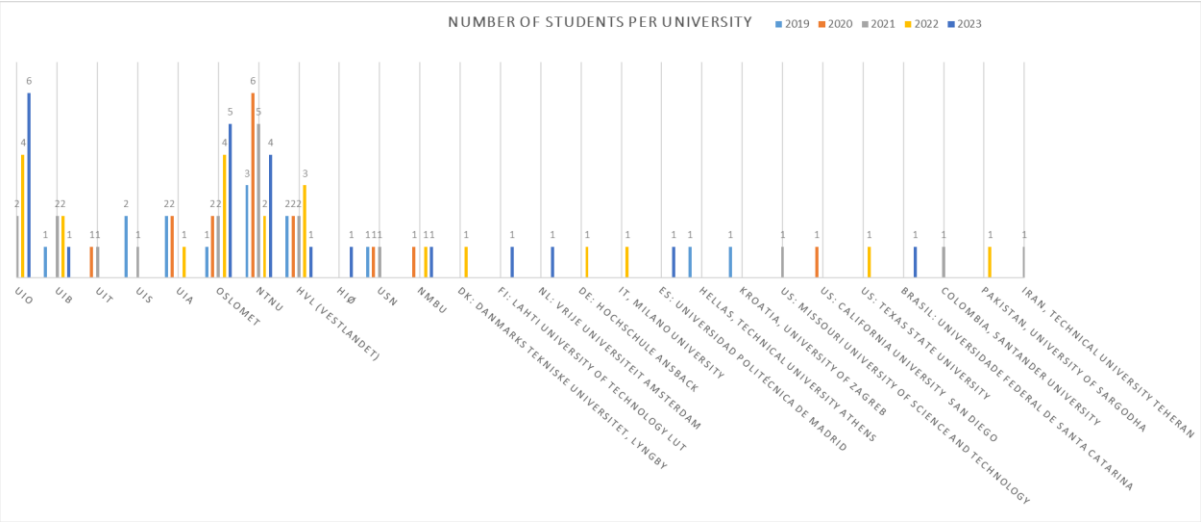
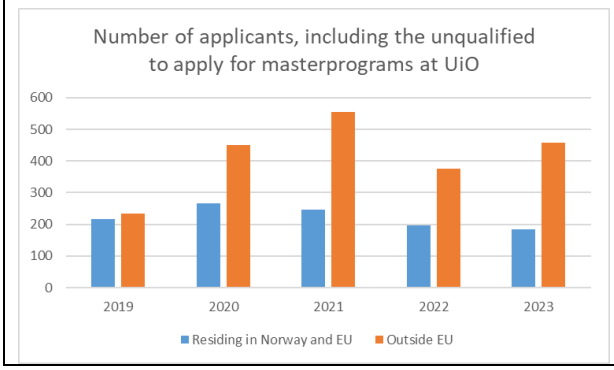


Figure A1.4. Number of students per university for 2019-2023.

Additional information
Table under reports the number of students who are qualified for master studies in Norway. The number of applicants increases when considering the total number of applicants, including those who are unqualified for admission to master programs at UiO, including those from outside EU/Norway. Total number of applicants per year are, respectively:

	Residing in Norway and EU	**Outside EU**	**In total**
2019	216	233	449
2020	266	450	716
2021	247	556	803
2022	196	375	571
2023	183	457	640



Completion rate for the RES program

Fig. A1.5 shows the number of students per year/TEK-course ONLY RES students, excluding students from other programs and/or taking single courses. As a note, some students take mandatory courses in the following years (instead of the first semester).

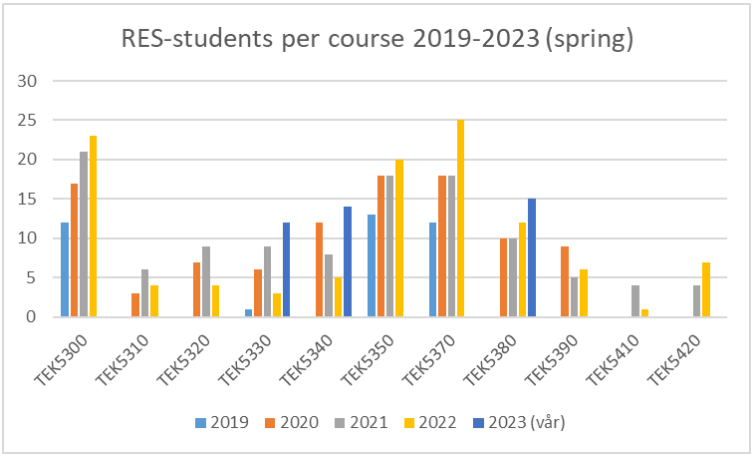


Figure A1.5. Number of RES students per course.

Number of students per year/TEK-courses all students (including external to RES program)

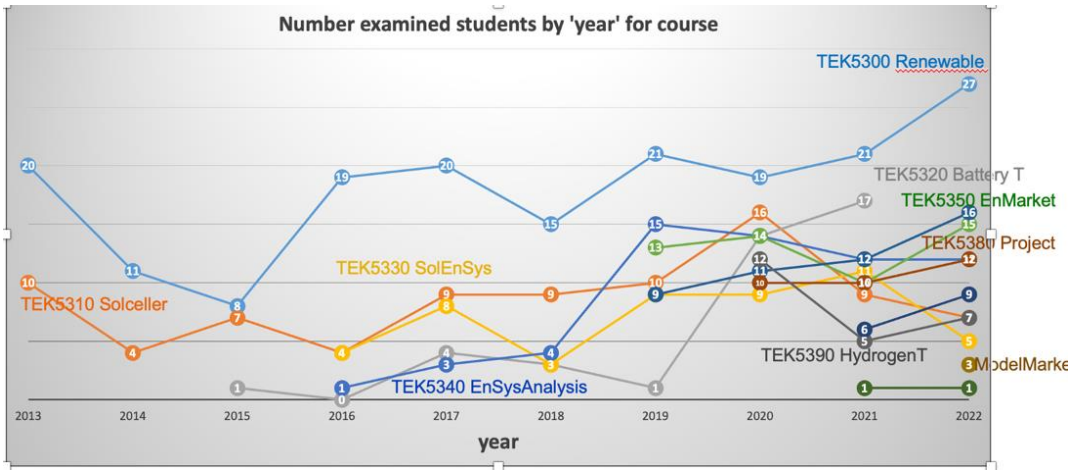


Figure A1.6. Number of examined students per year (until 2022) per course.

Appendix 2 - Evaluation of Renewable Energy Systems MSc courses

Input from course responsible

TEK5300/9300 – Renewable Energy: Science and Technology

Sabrina Sartori

1. *Describe the course and how it fits into the RES study program*

This course gives an in-depth overview of the main scientific principles and technologies related to harnessing and conversion of the earth's renewable energy sources, combined with a wide range of case studies. It gives a foundation about heat engine cycles, physical and mathematical principles of wind power/wind turbines, wave and tidal energy and harnessing devices, geothermal energy, solar thermal energy, the integration or renewable energy into grid/microgrid. In 2023 lectures have been also given about nuclear power, seen as relevant knowledge to complement the RES program. The course is mainly focused on scientific principles and technology development, however lectures also include life-cycle analysis and the process of decision making (planning, implementation, assessment involving the various stakeholders). The theoretical pensum is complemented by several excursions to research institutes, industries (e.g. wind power parks, hydropower plants) and group assignments. The course is complementary to the other mandatory courses in the first semester, and the project group course of the second semester. It gives also the basis to some specialisation courses (e.g. TEK5430).

2. *Provide an assessment of the previous knowledge the students need for taking the course*

Since the course includes heavy load of physics, mathematics and thermodynamics, prerequisites are students with bachelors in scientific subjects such as physics, mathematics, chemistry. To facilitate the common understanding of the class, some principles are repeated (e.g. Bernoulli´s equation etc.) and extra material is given as optional.

3. *Give an assessment of whether the course as it is given today has unwanted overlap with other courses at UiO*

Before developing the course in 2013, in-depth analysis of existing courses at UiO and nationally was performed. The course is still unique at UiO for the level of scientific depth. A course at BSc level at UiO – ENERGI4010, provides an overview of renewable energy technologies and is open to students from various faculties, therefore with a different scope than TEK5300.

4. *Give an assessment of whether the course has good academic relevance in relation to our MSc/PhD´s students thesis*

The course is relevant to MSc/PhD thesis since in most cases it provides background knowledge useful in the context of master thesis. In the assignments for PhD fellows, they are required to prepare an essay discussing their PhD thesis in relation to the relevant topic of TEK5300/9300.

5. *Give a description of further plans regarding improvements/changes to the course*

Since the development of renewable energy technology is progressing at a fast pace, the course is updated every year, including new assignments and strategy for front lectures and excursions. In addition to the current activities, laboratory activities may be included in the course. Workshops organized in collaboration with industrial partners/representatives may be considered in the future.

6. *Give an assessment of whether you think the course portfolio of RES study program is missing important elements*

The RES study program offer is mainly based on competences of ITS staff and adjuncts affiliated to the Energy Systems section. In 2023 new scientific staff has been employed (3 permanent and few adjunct positions), increasing and diversifying skills and competences. At the same time, the RES program has increased the number of its courses, including 5ETC courses.

A redesign of the RES program should be implemented introducing specialization lines after the first common mandatory semester. These specialization lines will need to be identified with internal assessment and will facilitate the students to choose the relevant courses for the relative field of interest. For instance, students interested in energy storage specialization could choose courses such as Batteries: technology and systems, Hydrogen technology, Innovation in energy technologies. A redesign of the RES program should also consider the rapidly growing demand of knowledge and competences from society at large and stakeholders.

TEK5330/9330 – Solar Energy Systems

Erik Marstein

1. *Describe the course and how it fits into the RES study program*

This course gives the student a good platform for understanding and handling PV power plants of all sizes. Given the importance of PV in the energy mix, one or more courses dedicated to PV are to be expected in a RES study program.

2. *Provide an assessment of the previous knowledge the students need for taking the course*

In its present form the students broadly have sufficient knowledge to follow the course. I am considering increasing the focus on modeling and analysis, but this will not happen this year.

3. *Give an assessment of whether the course as it is given today has unwanted overlap with other courses at UiO*

I don't think it has unwanted overlap with other courses at UiO.

4. *Give an assessment of whether the course has good academic relevance in relation to our MSc/PhD´s students thesis*

We have a lot of students on both MSc and PhD level, and the course is designed to be relevant for them.

5. *Give a description of further plans regarding improvements/changes to the course*

I am considering increasing the focus on modeling and analysis of PV power plants, but I will return to this at a later stage.

6. *Give an assessment of whether you think the course portfolio of RES study program is missing important elements*

It is good to see that the Solar cell technology course is continued at UiO. It is definitely possible to develop one or more new courses related to PV, either to a larger degree focusing on design, EPC, operations and maintenance of PV systems, new PV system technologies or integration of variable renewable energy production.

TEK5340/9340 – Energy Systems Analysis: Modelling, Methods and Scenarios

Pernille Seljom

1. *Describe the course and how it fits into the RES study program*

The course gives a comprehensive overview of energy system analysis, a discipline that gives insights into how energy systems can be designed and operated to cover future energy needs in a cost-effective and sustainable manner. The course gives knowledge on the interaction between energy production, infrastructure, storage, energy use and emissions, and how this can be modelled. This knowledge is valuable as energy system analysis is the basis for decision making in authorities and private energy companies related to the positioning and investments in the low-carbon transition.

The course can be split in three parts that are interwoven.

- The first part involves general knowledge of energy systems. The focus is on what are the required changes of the energy system to reach carbon-neutrality and what drives investments in renewable technologies to meet this target.
- The second part focuses on uncertainty in the energy transition, and how to consider for uncertainty in decision making by scenarios and demand projections. This part builds on acknowledge scenarios by e.g., IPCC.
- The third part is about energy system models, and how these models can be used to provide decision support related to the energy transition.

TEK5430 focuses on the use and market opportunities of renewable technologies and is therefore a supplement to the more technology-focused courses, as TEK5300, TEK440 and TEK5330. Further, TEK5350 is a good supplement to TEK5340 by providing knowledge on energy markets and regulation.

2. *Provide an assessment of the previous knowledge the students need for taking the course*

The course is designed to build on previous knowledge corresponding to the knowledge obtained in the bachelor's programme Matematikk med informatikk (bachelor). It can be an advantage with knowledge of operational research/ linear programming, but due to the mixed background of the students, an introduction to the necessary methodology knowledge is given. The course can be adapted if the background of the students will change in the future,

3. *Give an assessment of whether the course as it is given today has unwanted overlap with other courses at UiO*

I don't think it has unwanted overlap with other courses at UiO. Some students have mentioned that it could be beneficial to have TEK5340 before TEK5350.

4. *Give an assessment of whether the course has good academic relevance in relation to our MSc/PhD´s students thesis*

It has academic relevance for both MSc and PhD students. For PhDs, they need to do an extra assignment, an energy system modelling exercise, that needs to be presented and approved to pass.

5. *Give a description of further plans regarding improvements/changes to the course*

The energy system is changing rapidly, and the course content is revised each year to be relevant. The course content builds on experiences on the extensive energy system analysis activity that is conducted at IFE.

6. *Give an assessment of whether you think the course portfolio of RES study program is missing important elements*

There are many opportunities for expansion of the RES portfolio of courses, but what topics that should be included depends on the main strategy of ITS. Here are some suggestions for other courses:

- Material value chains and environmental impacts
- (Thermal energy systems)
- (Offshore wind technology and markets)
- Power grid – Operation and future development (DSO and TSO level)

TEK5350/9350 – Energy Markets and Regulation

Matin Bagherpour & Marianne Zeyringer

1. *Describe the course and how it fits into the RES study program*

This course gives a ground understanding of the functioning and modelling of market-based energy systems, starting with the classical markets like day-ahead electricity market and then continuing to the markets specific for renewable energy resources. It will give the students an understanding of the economics of different renewable energy sources with a focus on hydro, wind and solar, different options to integrate renewable energy into the energy market, types of policy instruments, regulation and institutional frameworks on a national and international level.

2. *Provide an assessment of the previous knowledge the students need for taking the course*

Some knowledge of linear optimization, economics and programming is very useful, though because of the diverse background of students we give them introductory lectures on mathematical modeling, economics and data analysis at the beginning of the course.

3. *Give an assessment of whether the course as it is given today has unwanted overlap with other courses at UiO*

I don't think it has unwanted overlap with other courses at UiO.

4. *Give an assessment of whether the course has good academic relevance in relation to our MSc/PhD´s students thesis*

It has academic relevance for both MSc and PhD students. For PhDs, the expectation on assignments/project is higher.

5. *Give a description of further plans regarding improvements/changes to the course*

Current changes in energy markets (energy transition, re-regulation, …) makes it inevitable to update course material. We need to revise the content each semester and add relevant topics.

TEK5370 – Grid and Smart Grid

Josef Noll & Shujun Zhang

1. *Describe the course and how it fits into the RES study program*

The course provides an overview of the Nordic power grid and its expected development. The starting point is the set of physical laws that govern the power transfer in the grid, including line characteristics, transformers and switching from alternate current (AC) to direct current (DC) and vice versa. The course includes an overview of the organization of the grid, its actors, control and dynamics. The transition towards Smart Grid, being fostered by the development of the Internet of Things (IoT), new sensors and smart meters offer opportunities for improved detailed and timely information on production, storage, control, and usage. The course thus provides the necessary knowledge of the grid infrastructure, essential for development and applicability of new theorems and models.

2. *Provide an assessment of the previous knowledge the students need for taking the course*

Given the variety of background of students, we see a limitation of applicable background knowledge of students. Thus, education on core topics like electrical grid transmission, technologies for transformers and

IoT needs to start from scratch. As the course is rather comprehensive on the topics, students need to enhance their knowledge to a high degree of self-studies.

3. *Give an assessment of whether the course as it is given today has unwanted overlap with other courses at UiO*

As the course focuses on physical aspects, related theory and applicability, some slides might be a repetition of topics from earlier studies. However, the system aspects, being the overarching outcome, are unique and have little, if any, overlap with other courses at UiO.

4. *Give a description of further plans regarding improvements/changes to the course*

The course is under constant development based on feedback from students and state-of-knowledge in the field. Two major revisions are envisaged for the upcoming years, being a) increased use of group lessons or discussion of difficult topics, and b) the introduction and goals of the groupwork in implementing participatory mechanisms for energy monitoring and control.

The structure of the exam is regarded as positive, as it is based on assignments, group work and known questions (see comments from students later on).

5. *Give an assessment of whether you think the course portfolio of RES study program is missing important elements*

Given the character of RES as an overarching study program, it is difficult to point to "lack of knowledge". However, our assessment is that study options like e.g. energy modelling, would make it easier for students to satisfy their interests.

TEK5380 – Project in renewable energy

Øystein Ulleberg

1. *Describe the course and how it fits into the RES study program*

The main objective with the TEK5380 project course is to perform a common student group work in the field of renewable energy, including topics such as energy storage in batteries and hydrogen and/or solutions for zero emission transport. The TEK5380-projects are to address actual real-world problems/challenges identified by private or public companies. It is important that the students understand the societal relevance of their project and can present their topic in a larger context.

In the first phase of the project work the students are expected to participate in the establishment and definition of the main objective and scope of work of the project. This means that the students are expected to be critical to the problem/challenge first presented to them. It is also expected that the students can establish a proper system description and are able to describe the main "customer/user" needs and requirements. Once this has been established the students are expected to perform a thorough literature review of the main topic(s) in the project, including study of relevant basic theory, technology, and possible system solutions. This must be documented properly (with references) in the written report and further referred to in the final presentation and oral exam.

In the second phase of the project the students are expected to focus more on their analysis of the problem/challenge identified. Here it is expected that the students find relevant data and modeling tools suitable to perform the necessary system analyses themselves. The data collection should involve the collection of statistical data, measured data, synthesized data, surveys, interviews, etc. The modeling should be based on well-established modeling tools (e.g., Matlab, Python, EES, etc.). When necessary, the students can make assumptions provided the nature and reasons for these are well justified and documented. The students must demonstrate that they are able to use different data and modeling methods and tools for independent system analysis. After the system analysis the students must demonstrate a good discussion of results, before they come up with some conclusions and recommendations for further work. It is also expected that the students reflect on the main findings and lessons learned in the project group work.

Finally, one of the main goals with TEK5380 is to teach the students how to work in teams. It is therefore important that the students demonstrate how they have planned, delegated tasks, and executed the project together. A successful project requires a good mix of skills, and it is therefore important that the students can show how their complementary skills have supported the project group work in a positive way. The final oral exam will be a test to verify that the students are able to present and communicate results from a large common project, written and verbally, both to specialists and a broader audience.

2. *Provide an assessment of the previous knowledge the students need for taking the course*

The background of the students taking the TEK5380 course ranges from those who have taken BSc in electrical, mechanical, civil, chemical, or process engineering (e.g., at USN, UIS, NMBU, NTNU or abroad) to those who have taken physics, chemistry, mathematics/IT (mainly at UiO, but some also from other national and international universities). A few of the students have already taken a master's degree in an other discipline (e.g., Petroleum, Process or Civil Engineering) and would like re-educate themselves in RES. A few of the

students also have some professional experience, and some even work part-time in a company while taking the course.

In general, the students have had an adequate background to perform the course. In the beginning of the course (first two lectures) there is a thorough process to make project groups consisting of students complimentary skills. Hence, if one student in a group does not have the necessary background or skills in a specific technical or scientific area, this is compensated by other groups members that may have this competence. There is also a possibility for the students to choose a project where they know they have the right background to full fill a role in the project. In the first phase of the projects the students are mainly challenged to do literature surveys, find relevant information, and refine the project scope of work and "problem" to be solved. This does not require a lot of background knowledge. Actually, this phase can be quite useful for further RES studies at UiO, and very often triggers the students interest in new areas and possible master project topics. However, in the second phase of the projects (after the mid-term project review) the student groups are challenged to dive into some more technical and challenging. The outcome of the deeper studies and system analyses performed in this phase of the project varies significantly, depending on the technical and scientific background of the students. The success of this part of the work is very often linked to the students theoretical/analytical and programming/modelling skills. The student groups that receive the top grades normally have 1-2 students that have good analytical and/or programming skills.

3. *Give an assessment of whether the course as it is given today has unwanted overlap with other courses at UiO*

The TEK5380 course does not seem to have too much overlap with other courses at UiO, since it is one of few courses that focus on teaching the student in Systems Engineering and Project Development/Management. Normally the topics for the projects are selected within wind, solar PV, batteries, and hydrogen for stationary and mobile (transport) applications. Hence, the students will be exposed to some of the scientific, technical, and practical challenges related to the key technologies for these applications. Hence, the TEK5380 course is a good match with TEK5300/9300. The students in TEK5380 are allowed to dig a little bit deeper into some of the RES technologies and systems that they have been briefly exposed to and learned about in TEK5300/9300. The students that end up doing a group project related to a specific topic (e.g., solar, batteries, and hydrogen) that is taught in later courses in the RES programme will have some overlap with these courses (e.g. TEK5330/9330, TEK5440, and TEK5390/9390).

4. *Give an assessment of whether the course has good academic relevance in relation to our MSc/PhD´s students thesis*

The TEK5380 course can in many ways "groom" the students to start thinking about their master projects. Several of the topics selected for student group projects have inspired students to continue with master projects with similar topics (e.g., Agri PV, battery, and hydrogen systems).

5. *Give a description of further plans regarding improvements/changes to the course*

The success of the projects is dependent on identifying good and relevant projects with external industry and user partners. It is also important to identify good internal and external co-supervisors for the students. The majority of external supervisors have so far come from IFE. This is because of the topics selected (wind, PV, batteries, and hydrogen) and the background and main affiliation of the person responsible for the course. In the future it would be good to have more supervisors from UiO ITS.

6. *Give an assessment of whether you think the course portfolio of RES study program is missing important elements*

The RES study program is well balanced on the topics covered, from general information on RES and system modeling to more specific technology focus (e.g., solar PV, batteries, and hydrogen). Hence, the students have an opportunity to learn more about RES on both a general and detailed level. It would strengthen the RES study program if there was offered a course in more detailed and technical energy systems modeling. It could also maybe be an idea to create an RES system laboratory course, either at ITS or in conjunction a laboratory at IFE.

TEK5390/9390 – **Hydrogen Technology**

Matylda N. Guzik & Sabrina Sartori

1. *Describe the course and how it fits into the RES study program*

The course: a) provides a general overview of the hydrogen technology value chain, including the fuel generation, conversion, distribution, storage; b) gives information on the industrial hydrogen utilization, c) integrates knowledge from a) and b) to inform about current and future hydrogen role from the renewable energy system perspective. A part of the course goes beyond purely technical analysis and includes relevant information from other disciplines, e.g., law or economy. The course is complemented by seminars & workshops organized in collaboration with the industrial partners/representatives, guest lectures and practical laboratory activities.

While the course has been designed to exploit the core competences of the scientific staff at ITS, at the same time it was thought to be a part of the course block dedicated to various energy storage technologies. Assuming that the master program will be upgraded and redesigned, the course should become part of a specialization line (for example "Renewable energy: production – storage – utilization").

2. *Provide an assessment of the previous knowledge the students need for taking the course*

The knowledge among students varies greatly, thus, the level of the course must be adjusted to the audience each year. If demanding some prerequisites (e.g., courses in physical chemistry or solid-state physics) and advanced subject knowledge, the topic can be taught at a more advanced level. However, taking into account that ITS has a limited number of students, imposing such entry criteria would limit the interest, thus the student numbers participating in the course. On the other hand, as this is only one of few known courses on hydrogen technology available at Norwegian universities/high schools, maybe the course should be redefined and offered as a module I and II, with the former being more theoretical and provided also in a digital form (alternatively taught at Blindern). In this way more students could gain awareness about the course itself and hopefully, some of them would be a attracted to join the more practical module II.

3. *Give an assessment of whether the course as it is given today has unwanted overlap with other courses at UiO*

We are not aware of overlaps. The course integrates some theoretical knowledge from various fields of chemistry and physics, presented however from a new perspective. As for the technology part, none of the courses at UiO covers the topic.

4. *Give an assessment of whether the course has good academic relevance in relation to our MSc/PhD´s students thesis*

Since the course is based on the core competences of the scientific staff at ITS and at the same time, involves activities at the ITS new research facility, in our opinion, it is a relevant course for the development of research and educational offers at the department. Because of that, we think it should become a mandatory course (and not elective) among students who decide to take the "energy storage" specialization, so that ITS/energy system section can build more activities based on the "in-house" knowledge and competences.

5. *Give a description of further plans regarding improvements/changes to the course*

See point 2. Furthermore, since the specific technology and regulatory development is progressing at a fast pace, the course is updated every year. Extensive use of the new laboratory should be implemented at some point, but this requires the presence of additional skilled technical support that should also be partly responsible for the lab operation.

6. *Give an assessment of whether you think the course portfolio of RES study program is missing important elements*

The RES study program should be redesigned based on the current number of courses and new specialization lines should be implemented. During this process, the missing links (necessary courses to build and complete the coherent master program) shall be identified. While the master program in Renewable Energy Systems was one of its kind once initiated, at least in the Oslo/Viken area, in the meantime, the number of attractive and interesting study offers similar to ours, has grown rapidly and soon (if not already) we will become just one of many. In order to keep students interested in the program in the next years, and at the same time to make sure that the ITS location is not a hindrance, the offer must be very unique, and more effort is needed to redesign and redefine the current offer. Obviously, the extended specialization lines, that would integrate the skills and knowledge of newly hired scientific staff, should be proposed and developed.

TEK5420 - Norway's Energy Transitions: Policy Directions and Challenges

Tor Håkon Jackson Inderberg

1. *Describe the course and how it fits into the RES study program*

The course is a rather holistic approach to the Master program in Renewable Energy Systems but focuses on the societal and political challenges of the ongoing energy transitions. As a social science-based course it is a supplement and complementary knowledge to the program's emphasis on more technical knowledge, but it forms a highly useful overview of the challenges and system-level opportunities lying in the transitions. I think the course fits very well particularly together with the course on energy markets and regulation, and with the modelling course, as they too are system-level and quite holistic.

2. *Provide an assessment of the previous knowledge the students need for taking the course*

The course requires knowledge and understanding of energy technologies and system properties. Some knowledge and interest about societal and political challenges are needed too.

3. *Give an assessment of whether the course as it is given today has unwanted overlap with other courses at UiO*

I do not believe it is much of unwanted overlap to other ongoing courses.

4. *Give an assessment of whether the course has good academic relevance in relation to our MSc/PhD´s students thesis*

I believe the course has high relevance, although perhaps sometimes unrealized potential in the students' theses. The potential lies in boosting the students' understanding of relevance in practical implementation, technology diffusion in society, and politically feasible applications, in addition to cost-optimal and technologically feasible energy solutions.

5. *Give a description of further plans regarding improvements/changes to the course*

The course is developed and adapted every year to the most important societal, political, and energy system developments. This is perhaps the most important area for development. There are some challenges in teaching social science/political theory to the students in the course, but solutions have been found for this, I think.

6. *Give an assessment of whether you think the course portfolio of RES study program is missing important elements*

The only significant topic I have noticed is a complete lack of consumption side. This is increasingly important also in Norway (with smart meters, recent adoption of a power tariff, and increasing levels of charging and unregulated electricity production).

TEK5430/9430 (5 ETC) Innovation in Energy Technologies

Sabrina Sartori & external lecturers

1. *Describe the course and how it fits into the RES study program*

The course is interdisciplinary, at the intersection of technical and social fields of knowledge. It focuses on innovations in the field of energy systems, looking at innovative energy technologies not as separate entities, but as made up of systems of related technological and non-technological elements where we also need to understand the social drivers and barriers in technological change in energy and energy systems, including markets, institutional conditions, consumer preferences/behaviours and more. Emphasis is put on the concept "technological innovation system" and "socio-technical" transitions. The theoretical foundation from lecturers specialised in innovation studies at TIK (Centre for Technology, Innovation and Culture, Faculty of Social Sciences at UiO) is complemented with specific real case studies from academic and industrial energy technology innovations. The course is offered as part of the RES program and open to students from other faculties. It fits well to the RES program in that it gives our students a critical mindset and knowledge complementary with other courses of the RES program.

2. *Provide an assessment of the previous knowledge the students need for taking the course*

The course requires a general understanding of energy technologies and system properties. The necessary theoretical foundation is given in the course.

3. *Give an assessment of whether the course as it is given today has unwanted overlap with other courses at UiO*

I do not believe there is an overlap with other ongoing courses.

4. *Give an assessment of whether the course has good academic relevance in relation to our MSc/PhD´s students thesis*

The pilot year for this course was January/February 2023. We believe the course has good academic relevance for students´ thesis. This will be explored in the near future. The potential lies in the focus on the "social

legitimation of new technologies" – a very important part of wider diffusion and uptake of new technologies for the development of a society.

5. *Give a description of further plans regarding improvements/changes to the course*

During the course students are exposed to specific case studies presented by international guests of high calibre, experts in innovation, and experts from industry. These may be different year by year, depending on the needs and evolution of the topic. Peer to peer and project-based group work, where the students learn how to perform Technological innovation systems (TIS) analysis, are also adapted every year.

TEK5440 – Batteries: Technology and Systems

Hanne F. Andersen & Julia Wind

The course is a renewed version of a previous course given in the period 2015-2022 (Battery Technology TEK5320/9320, main responsible Martin Kirkengen (collaboration with Sabrina Sartori). Course discontinued since Kirkengen resigned from his adjunct position).

1. *Describe the course and how it fits into the RES study program*

The course provides an introduction to battery technology and its application within renewable energy systems. Starting with battery components and battery design, with a particular focus on Li-ion-based solutions, the course gives insight into battery performance and the battery value chain. It also provides an in-depth overview of various battery applications, ranging from consumer electronics to electric vehicles and stationary energy storage.

Other relevant topics include battery testing, safety, modeling, and sustainable re-utilization. The theoretical knowledge is expanded by practical activities in battery laboratories, as well as group work and practical assignments.

2. *Provide an assessment of the previous knowledge the students need for taking the course*

The course builds upon knowledge obtained at the bachelor's level within natural sciences and/or engineering. This includes basic chemistry, physics, and materials science.

3. *Give an assessment of whether the course as it is given today has unwanted overlap with other courses at UiO*

As far as we know there are no courses with unwanted overlap.

4. *Give an assessment of whether the course has good academic relevance in relation to our MSc/PhD´s students thesis*

It has academic relevance for both MSc and PhD students. For PhDs, the expectation on assignments/project/lab work is higher.

5. *Give a description of further plans regarding improvements/changes to the course*

Rapidly changing technology - course will be updated accordingly each year.
Evaluation of relevant industry guest lectures.
Additional material for further in-depth reading will be assessed and provided.

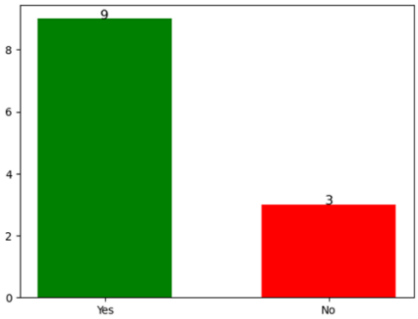
Questions to MSc students – part 1

5. How do you think the course offer at MSc level is? Are your academic needs met?
6. Are there particular topic areas that you would like the study program to develop, in the form of additional courses?
7. In general, what do you think about the teaching style of the MSc courses? Is there anything you would like to particularly highlight as positive or negative?
8. Any other comments?

A number of 12 current students (that started the master in 2022) have answered. The survey and collection of answers from the students have been done by a fellow student who completed the master program in June 2023. All students answered during live interviews.

Q 1. How do you think the course offer at MSc level is? Are your academic needs met?

Of the total answers, 9/12 feel their professional needs are met as illustrated by the figure.



Amongst those who answered yes, a good variety of courses was pointed out amongst the reasons for this. The group that answered no, did not like the variety in courses and pointed out dissatisfying lecture qualities.

Q 2. Are there particular topic areas that you would like the study program to develop, in the form of additional courses?

From this question there was a large portion of the candidates (11/12) that said wind energy would be interesting. Some also stated that hydropower was desired.

Q 3. In general, what do you think about the teaching style of the MSc courses? Is there anything you would like to particularly highlight as positive or negative?

The majority of students agree that the teaching methods are good in most cases. However, when asked to point out room for improvement there was a large common ground on certain aspects of some courses. These are listed as follows:

- 8-hour lectures in a day for a course is too long
- Interactive element should be implemented when possible
- Assignments should be handed out only if they receive feedback after grading (pass/not pass)
- 60 slides power points where the lecture only uses 12 of the slides is frustrating.
- Usage of group lessons (“gruppelærer”) should be enhanced to deepen the knowledge of difficult topics

When asked to point out specific positive elements the most answered are as follows:

- Time and industry relevant
- Engaged lecturers that motivate students.
- Use of active elements and class discussions.

Q 4. Any other comments?

In further comments most students said no, although some pointed out that the need of course materials should be distributed and easy to find on canvas, not just power points but side information to the topics as well.

Appendix 3 – Feedback from students about learning environment

Questions to current MSc students – part 2

5: How is the cohesion of your cohort? (with fellow students in/across research groups)

Most students have good relationships with their fellow classmates, some view them as colleagues only and not friends. However, no one stated that they had a bad experience with the social dynamics. On the follow up question regarding the students in the grade above them, most students said they had good contact with the students that are present at campus.

6. Do you have friends in your research group?

The same ratio as seen above in question 5, where those who answered okay view them more as work colleagues than friends.

7. Are social activities organized in your group?

Although 9/12 answered yes to this, they also stated that they did not show up in many of these events due to other reasons, only three were not aware of these social activities.

8. Are you well integrated in your environment because of what was arranged, or because of your own efforts?

Most of the students here answered 50/50 between own initiative and university initiative.

9. What do you remember from the master sponsor week? How did you experience it?
From the students that did participate, they remember it as a fun start of the master program. The consensus was that it was a fun and informative week.

10. What do you think is the reason for having the master sponsor week?

In consensus all students answered, "To get to know your fellow classmates" and gain better connections.

11: What is the structure of your courses like?

Mostly good, as previous question 3. In addition, some pointed out the examination strategy used by Josef Noll (TEK5370/90) and Erik was extremely positive.

12. How is the collaboration between students in the various courses?

12/12 students reported good collaboration across subjects with their fellow students.

13. Do you think someone will follow you up if you fall outside? Whom?

10/12 answered yes that someone will make contact and talk to them if they fall out the group. Of these, 9/10 answered that it would be a fellow student, and 1/10 answered it would be a lecturer or some other entity.

14. Do you feel that the RES program has provided you with a network?

12/12 feel they have gained a social / student network. in addition, 9/12 feel like they have gained a work-related network.

15. Are you proud to be a RES master student?

Consensus is yes, all participants are proud to be part of the RES program.

Appendix 4 – Survey about relevance to working life

Below are the data and information collected via a survey related to the relevance to working life of RES, according to former students.

1. To what extent were the job opportunities after completing your studies important in choosing RES as a field of study?

I hvilken grad var mulighetene for å få jobb etter endt studie viktig i valg av FENS som studieretning?

Antall svar: **12**

Svar	Antall	% av svar	
Svært viktig	9	75%	75%
Viktig	2	16.7%	16.7%
Mindre viktig	1	8.3%	8.3%

Comments from students:

- *Nice to have a job.*
- *There were many opportunities due to the broad knowledge from the study. Had opportunities in, among other things, auditing and engineering positions in various fields of study.*
- *I believe the job market in general is interested in people with a master's degree.*
- *It was very motivating to know that the renewable energy sector would expand and that more positions would become available.*
- *I study and studied what I found interesting. A job was not a factor that guided the choice of study.*
- *It seemed forward-looking and diversified. The focus on systems instead of just core technology gave a more engineering-oriented approach. In addition, incorporating political and economic challenges gives the program a weight that is hard to get from other places.*

2. To what extent did you receive information/guidance about the job market and relevant employers during your course of study?

I hvor stor grad fikk du informasjon/veiledning om arbeidsmarkedet og relevante arbeidsgivere underveis i studieløpet?

Antall svar: **12**

Svar	Antall	% av svar	
I stor grad	1	8.3%	8.3%
I noen grad	5	41.7%	41.7%
I mindre grad	6	50%	50%

Comments from students:

- *This was rarely discussed in daily life except among the students. We had a lot to do with IFE, but they didn't have any vacancies that I found interesting. It would have been useful to*

have more connections to the industry and potential employers through tasks and seminars/company presentations.

- *I was introduced to the biggest companies in renewable energy through the various subjects in the study. Either through the professor who worked in the company themselves or various projects.*
- *Guidance about the job market? What does that mean?*
- *There was little talk about job opportunities. A seminar with companies would have been desirable. In the hydrogen subject, we had such a professional day where one could network with potential employers*

3. How long did you search for jobs after you graduated before being employed?

Hvor lenge søkte du jobber etter at du var uteksaminert før du fikk jobb?

Antall svar: 12

Svar	Antall	% av svar	
Innen 1-6 måneder	1	8.3%	8.3%
Innen ett år	1	8.3%	8.3%
Over ett år	0	0%	0%
Før jeg var ferdig	8	66.7%	66.7%
Fortsatt ikke i relevant jobb	2	16.7%	16.7%

4 How important was the specific education you received from the RES program in getting your first job?

Hvor viktig var den spesifikke utdanningen du fikk fra FENS-programmet for at du fikk din første jobb?

Antall svar: 12

Svar	Antall	% av svar	
Svært viktig	3	25%	25%
Viktig	6	50%	50%
Mindre viktig	4	33.3%	33.3%

Comments from students:

- *In my situation, it was mainly a combination of my previous education with the UiO degree that was decisive.*
- *Mostly because the study is less known. People who hire are often more interested in more established/well-known fields of study.*
- *Not relevant.*
- *Haven't got a job yet, but apparently need to answer :) *
- *The employer had hired others with the same education before and felt confident that they were well-qualified candidates for that reason.*
- *The education here gave me weight and a versatile mind, which helped me stand out in the job market.*

5. Do the most relevant industries within the job market have knowledge of RES as a study program?

Har de mest relevante bransjene innen arbeidsmarkedet kjennskap til FENS som studieprogram?

Antall svar: **12**

Svar	Antall	% av svar	
I stor grad	1	8.3%	8.3%
I noen grad	5	41.7%	41.7%
I mindre grad	7	58.3%	58.3%

6. *To what extent do you think the RES program as a whole is relevant to the Norwegian job market? (If foreigner, you can choose to address this based on your own country)*

I hvor stor grad synes du FENS-programmet i sin helhet er relevant for norsk arbeidsliv?

Antall svar: **12**

Svar	Antall	% av svar	
I stor grad	9	75%	75%
I noen grad	3	25%	25%
I mindre grad	0	0%	0%

Comments from students:

- *Based on my experience as a consultant in a large company, FENS is very relevant. Out of many thousands of employees, there is a small group that has experience and works on the topics that were discussed, even though management emphasizes sustainability, etc., daily.*
- *The study provides a comprehensive understanding that prepares a potential employee to offer valuable insights into various issues.*
- *It's hard to answer when I haven't gotten a job. But it seems like there is more demand for practitioners than theorists.*
- *There is clearly great relevance; this program made me stand out from the crowd and made me more interesting to employers.*

7. All in all, how satisfied/dissatisfied are you with the academic/professional outcomes of the education within the RES program?

Alt i alt hvor fornøyd/misfornøyd er du med det faglige utbyttet av utdanningen innen FENS-programmet?

Antall svar: **12**

Svar	Antall	% av svar	
Svært fornøyd	5	41.7%	41.7%
Fornøyd	7	58.3%	58.3%
Noe fornøyd	0	0%	0%
Misfornøyd	0	0%	0%

Comments from students:

- *I missed technical subjects on wind power, but otherwise, it was very good. Good selection and high expertise.*
- *That's correct, I took a bachelor's degree in MENA before I started with FENS. I am very satisfied with the academic outcomes because I was looking for a more technology-oriented education, which I got by completing this master's degree.*
- *I would have liked even more on hydropower, nuclear power, and fossil power.*