REPORT

EUROPEAN POSTGRADUATE PROGRAMS IN SUSTAINABLE ENERGY

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SUMMARY

While European graduate and post-graduate programs in sustainable energy can vary in terms of duration, content, curriculum, level of detail, degree, etc., there are a few common characteristics that can be used to segment available programs. The main classification criteria include - among others - topic/sector, duration, credits awarded, type of degree and delivery mode.

Most programs are full-time studies that take between 12 and 24 months to complete and wrap up with either a Master thesis or an equivalent research project. Courses are typically provided in traditional face-to-face teaching setup on-campus. The main program modules consist of lectures and seminars that are credit-based and conclude with written exams at the end of each semester. Some programs are offered as part-time option with distance-learning arrangements and online resources for self-study. Brief on-campus workshops or exams are often required for distance learning programs. Full online programs are designed for part-time study and have a typical duration of 2 to 3 years.

Between 80 and 90% of all graduate and post-graduate courses award a Master of Science (MSc), sometimes with a specialization (e.g. architecture, urban planning, engineering management etc.) or even a double degree. Some courses finish with a Master in Engineering (MEng) or MBA. Most programs are offered based on a common credit system (ECTS) that is approved by the majority of European universities. Several courses offer other degrees, e.g. Diploma or Certificate that correspond to a lower number of credits and provide an alternative to a full Master program.

English is the prevailing language with some programs available in multiple languages. Proof of language proficiency\(^1\) is required for admission as is an undergraduate degree (BSc or equivalent). Admission procedures may include an interview or proof of relevant professional experience, especially when degree requirements are not fully met. Some universities in Spain, France and Germany offer programs in local language often tailored more to national students and job market requirements.

In terms of contents, some programs have a more general curriculum, for example renewable energy in general, others are more narrowly focused on technology such as wind, solar, biofuels etc. By using a wider definition (“All Renewables” in the – IRENA Renewable Energy Learning Partnership [IRELP] database), over 100 programs in Europe alone provide a huge selection of topics and specializations from general renewables to energy efficiency, building energy management, power plants and numerous options related to specific renewable energy technologies.

Most programs attract students with above average grades from all over the world. Students’ motivations for taking a Master program in sustainable energy can range from general interest in renewables to detailed career or business venture plans. Most international students from Asia, Latin America or Africa use their education in renewables to launch a career in their home country.

Program cost, i.e. tuition fees vary and can total more than €10,000 for multi-year courses.

\(^1\) TOEFL, IELTS or similar for English language proficiency
BACKGROUND

As an information platform dedicated to energy efficiency and sustainable energy, Leonardo ENERGY receives frequent inquiries from individuals interested in academic programs in sustainable energy. Those information requests are handled mostly on an ad-hoc basis. In cooperation with the EUREC, Leonardo ENERGY is working towards a taxonomy of graduate and post-graduate education programs in the field of sustainable energy. EUREC is managing the European Master in Renewable Energy, one of the leading European Master programs and thereby acting as the facilitator between research centers and universities active in the field of renewable energy technology.

The IRENA Renewable Energy Learning Partnership (IRELP), a project of the International Renewable Energy Agency (IRENA), was formed to increase awareness of, and broaden access to education and training in the fast-growing sector. IRELP is the largest global database of renewable energy education opportunities and resources, currently offering more than 2,500 workshops, courses, degree and certificate programs, internship opportunities, webinars and training guides. With active users in more than 180 countries, IRELP is helping students, aspiring professionals and future decision makers embark on exciting renewable energy careers.

INTRODUCTION

With the growth of the renewable energy sector, well-educated professionals are in demand. Academic programs offered by universities provide the required education and specialization for those looking for a career in the renewable energy sector.

Master and similar postgraduate programs typically build upon Bachelor or equivalent undergraduate science degrees, sometimes coupled with professional experience. PhD and post-doctoral courses require a Master degree or PhD. Many programs offer specializations within the renewable energy sector with education for specific technologies such as photovoltaic, wind, geothermal or biomass. Duration and thematic focus of programs can differ widely. Programs also vary in terms of general setup and delivery format, cost, language, requirement of an internship or practical term as part of the studies. Several programs are international or multi-university, i.e. include attendance of schools in more than one country and are offered as joint programs between several universities and research institutes.

The vast number of available sustainable energy education programs calls for a general review of course options and a segmentation of programs that can be offered as initial “go-to” resource for interested students. IRELP has proven very valuable for a general segmentation and categorization of academic programs offered globally. Based on its database structure, program searches can be filtered along key segmentation criteria such as thematic content and focus, program duration, type of degree (certificate, diploma etc.), program admission requirements and more. However, the vast number of available sustainably energy education programs calls for a general overview of the different types of course options and a segmentation of programs that can be offered as an initial “go-to” resource for interested students. IRELP has, however, proven very valuable for a general segmentation and categorization of academic programs in Europe. Based on its database structure, program searches can be filtered along key segmentation criteria such as thematic content and focus, program duration, type of degree (certificate, diploma etc.), program admission requirements and more.
LANDSCAPE OF PROGRAMS IN SUSTAINABLE ENERGY IN EUROPE

Based on IRELP, there are more than 120 graduate and postgraduate programs available in Europe. Almost one third of programs are focused on education around all aspects of renewable energy. Between 15 and 25 programs are offered for each of the specific renewable technologies, including solar/photovoltaics, wind, geothermal and bioenergy. Around 21% of programs treat other topics around sustainable energy (e.g. buildings, energy management, urban systems etc.) or are cross-cutting courses.

![Figure 1: Thematic Focus of European Graduate and Postgraduate Programs](image)

The leading countries in terms of number of programs in sustainable energy include the UK, Germany, France, Spain and Sweden. Academic programs have evolved and grown with the development of the renewable sector in these countries. More than 60% of programs are taught in English; most programs outside the UK are also offered in English given the students’ international background. Some programs are taught in Spanish, French or German in addition to English or offer introductory lectures, i.e. first semester modules in local language with the remainder of the program in English.

While many programs have been developed recently, within the last 3 to 5 years, some of the more established programs, for example the Postgraduate Programme Renewable Energy (MSc) offered by the Carl-von-Ossietzky University of Oldenburg (Germany) have been around for 25 years now. Mature and established programs often have a strong alumni community and professional network enabling new students to connect with professionals and companies in the sector. Universities offering new programs are still working on promotion and refinement of course details and overall concept. But all programs put a strong emphasis on quality of education over quantity of students.

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2 [http://irelp.org/courses/](http://irelp.org/courses/) with filter “Europe”, “All Renewables”, “Graduate” and “Postgraduate”

3 Most programs cover several topics but usually have one focal theme. Data for the chart is based on multiple mentions per program.
EUROPEAN PROGRAM CHARACTERISTICS

A review of leading Master programs, graduate and postgraduate courses in renewable energy in the IRELP database provides the basis for a general characterization and typology of programs.

Graduate and postgraduate programs in renewable energy or specific fields, for example solar/ PV, wind or geothermal are very technology and engineering driven and focused on real-world work environments. Courses in areas such as energy efficiency, industrial ecology, energy management and general sustainability are often slightly more academic and multi-disciplinary in nature. Here, the curriculum is focused on providing a broader conceptual and interdisciplinary approach to energy management and sustainability.

Between 75 and 85% of all programs in Europe award a Master of Science degree. Other degrees include Master of Engineering, MBA, postgraduate Diplomas or Certificates. PhD programs account for less than 10% of all postgraduate programs in sustainable energy. In terms of time commitment and delivery mode, close to 90% are full-time courses with face-to-face instruction on-campus. Approximately 10-15% of programs offer part-time study options combined with distance learning and online study resources. Relatively few “online only” courses exist, for example, the Master Propio on Renewable Energy of the University of Zaragoza, the MSc in Renewable Energy and Energy Management of the University of Ulster or the Online Master in Photovoltaics offered by the University of Freiburg.

In terms of program duration, 12 to 24 months, i.e. 3 to 4 semesters is the prevailing program length. This typically includes the completion of a Master thesis or an equivalent research project – often with a research institution or a company in the renewable energy sector. Most Master programs take between 16 and 24 months (3 to 4 semesters full-time study) to complete. Certificates and Diplomas may range from 9 to 12 months due to lower credit and course load and can be considered as “partial Master degrees” as they share courses and lectures. Postgraduate certificates and Diplomas are most common in the UK. There are virtually no graduate or post-graduate courses with duration of less than 6 months. All graduate and post-graduate programs require a Bachelor or equivalent undergraduate degree for admission. Work experience in a related field or an admission interview may be required, especially when the number of applicants exceeds the number of available program spots. In rare cases, students with extensive relevant work experience may be admitted to a program without a Bachelor or other required degree.

University programs in sustainable and renewable energy offer spots to a limited number of students that are taught by an inter-disciplinary team of teachers and industry experts. Several programs are hosted in cooperation with partner universities and require students to attend courses at a second university in a different country. Most programs also include an internship and close mentorship by academic staff. An emphasis on individual tutoring is considered essential in helping students find their niche, interests and strengths. Accordingly, universities admit anywhere from 15 to 75 students per year. The number of applicants for leading Master programs typically exceeds the number of available spots. Most universities consider their program(s) in renewable energy as high-end and specialized thereby attracting students with well above average grades and capabilities. Some of the stand-alone Master programs offered by universities that are part of the EUREC European Master in Renewable Energy may share basic lectures and modules on renewable

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4 Examples include the EUREC Master in Renewable Energy, the Nordic Master in Sustainable Urban Transitions, the Master in Innovative Sustainable Energy Engineering or the European Wind Master.
energy technologies with the EUREC Master. Programs on general renewable energy typically provide an option for specialization on a specific technology (e.g. solar, wind or geothermal) during the second part of the program. This specialization is, however, not as deep as a dedicated Master program that is centered on a particular technology.

Final grades are made up of exams and the evaluation of the Master thesis or equivalent project. The majority of Master programs are accredited for further post-graduate studies, e.g. a PhD program as they follow the European Credit Transfer and Accumulation System (ECTS). The average program course load is 30 credits per semester according to the ECTS system. Depending on the type of program and specialization, Master degrees in renewable energy are awarded after successful completion of at least 90 credits (e.g. EUREC European Master in Renewable Energy) or 120 credits if the program is more specific (e.g. MSc Solar Energy, University Perpignan; MSc Energy Management and Sustainability, EPFL). Very few master programs have less than 90 credits and some can be completed in only 12 months full-time study.

Based on the required internships and project work, many Masters programs create strong ties between students and industry facilitating employment in the renewable energy sector upon graduation.

**STUDENTS**

Programs in sustainable energy in Europe attract students from all global regions. International students come from China, India, Latin America and Africa to acquire an education that is rarely offered in their home country. Additionally, a Master degree from a reputable European university does not only improve the chances for employment in the home country but also in Europe.

Most students have a technical background and an engineering related degree when entering a Masters program in renewable energy. Electrical, mechanical or civil engineers with a Bachelor degree are most common with fewer physics, mathematics or microtechnology majors. Students with a business or management background are rare. Given the number of available spots, admitted students are usually above average performers leading to very low failure rates.

Students’ motivations for taking a postgraduate course in renewable energy differ but career focus is the dominant aspect given the current job market. A Master degree in renewable energy is extremely helpful in acquiring the know-how needed for a specific profession and dramatically increases the odds in finding employment in the renewable energy sector. Few students start a Master program with the intention to start their own business in renewable energy, often in their home country. Another key motivation is the intention to contribute to a positive change in today’s and future energy portfolio. Many, especially younger students are “do-gooders” with the intention to contribute to a sustainable energy future by working in the renewable energy sector.

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5 Sharing of lectures and modules also applies to some of the Nordic Master programs offered by the five Scandinavian universities (KTH, DTU, NTNU, Chalmers, Aalto)

6 The Master propio programs offered by the University of Zaragoza are completed after 60 to 75 credits and 9 month on-campus / 2 years online study, including the Master project.
W HAT TO C ONSIDER WHEN C HOOSING A PROGRAM?

Despite varying program designs, there are a few key selection criteria that can help students to narrow down their choice of graduate or postgraduate programs and find the most appropriate course for their needs. The main selection criteria include:

1. **Topic/ sector**: What area or technology does the student want to focus on?

   Program topic, sector or specialization are the most decisive criteria for students when choosing a program. The topic focus and contents of a program will determine the specific options for a career in sustainable energy. Programs can generally be segmented into three main thematic groups:

   a. **Programs with focus on renewable energy technology providing a general education** and background on all areas of renewable energy, including renewable resources, technologies, legislation, policy, energy markets and economics, etc. Those programs can be an entry into a career in the renewable energy sector or a stepping stone for further specialization in a particular technology.

   b. **Programs with focus on a specific renewable technology** such as solar/ photovoltaics, wind, biomass, geothermal etc. These programs are often more technology and engineering driven and provide a very detailed understanding of a renewable energy technology.

   c. **Multi-discipline and cross-cutting programs** focus on concepts rather than specific technologies. Examples include courses in sustainability, energy management, energy efficiency, urban sustainability etc. A more holistic approach to energy and energy systems characterizes these programs.

   The IRELP database offers “program sector” (topic) as first search and selection criteria and distinguishes between 9 sectors related to renewable energy.

2. **Credits**: Virtually all graduate and postgraduate programs offered in Europe are aligned with the ECTS\(^7\) system for credits. The number of credits is based on workload in terms of hours in an academic year or semester. To this extent, credits correlate with the duration of a program. Typically, one semester includes 30 to 60 credits\(^8\). Additional credits are allocated to the Master thesis or project. Most Master programs are awarded after successful completion of 90 or 120 credits. There are slight differences between countries based on national education regulations but degrees in Europe are usually transferable and acknowledged by most universities across the EU. Programs with higher credit load typically provide more education and training based on the number of lectures and seminars.

3. **Duration**: The length of the program may be an important consideration for students as programs build upon previous education or existing degrees. Depending on the motivation of the student, a short program might be preferable to a more comprehensive course. Programs can range anywhere

\(^7\) [http://ec.europa.eu/education/lifelong-learning-policy/ects_en.htm](http://ec.europa.eu/education/lifelong-learning-policy/ects_en.htm)

\(^8\) In the UK, Master programs may award up to 60 credits per semester, e.g. the Master in Renewable and Sustainable Energy Technologies of Northumbria University. Full Master – 180 credits; PGDip – 120 credits; PGCert – 90 credits
from 9 months (PG Certificates or Diplomas) to 3 years (full Master, including distance learning) depending on the type of degree, delivery mode and complexity or even longer for PhD programs.

4. Type of degree: An important classification of graduate and postgraduate courses is the final degree awarded. The degree corresponds roughly with the number of credits and the duration of the program. Although most programs conclude with a Master of Science (MSc), few programs offer a Master in Engineering or Postgraduate Diplomas or Certificates for shorter courses. Diploma or Certificate programs typically consist of the first one or two semesters of a Master program sharing lectures and modules. Some of the programs offer a double degree, i.e. two fully recognized Master degrees with possible specializations or a Master degree with an additional Diploma in the specialization subject.

5. Delivery mode: Face-to-face and on-campus courses are most common and attract younger students that often continue their studies after completing their Bachelor degree. On-campus programs are full-time and usually do not allow for part or full-time work. This might be an important consideration for those already working in the industry and looking for an add-on degree or education. Most face-to-face programs offer some online resources to support in-class lectures and seminars. Full online distance learning programs are less common but allow students, especially those with employment to work towards a Master degree while working part-time. Online programs are typically part-time courses with few on-campus days each semester. Some universities offer exam options run by proctors in countries worldwide to international students.

6. Course language: English is the dominant language throughout Europe for programs in sustainable energy. German, French and Spanish universities, however, offer Master programs in local language catering more specifically to local students and job markets. English language capabilities are considered essential for a career in the renewable energy sector and many programs offer or require studies and/ or internships in more than one country. Few programs are taught in more than one language during the first semester to give students the opportunity to familiarize with both the topic and the English language.

7. Internationality: Several programs are offered as joint initiative between multiple universities sharing lectures, modules or specializations. Attendance of universities in two different countries may be required and can be part of the program. Examples of joint programs include the EUREC European Master in Renewable Energy, the Nordic Master in Sustainable Urban Transitions or the Master in Innovative and Sustainable Energy Engineering. Other programs offer internships or studies abroad with affiliated universities, for example, EPFL with their branch in UAE. The international dimension of a Master program can be decisive for a later career choice.

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9 Postgraduate Diplomas (PG Dip) and Certificates (PG Cert) are mostly awarded in the UK for programs with less than 90 ECTS credits

10 The European Wind Master and the Master in Innovative Sustainable Energy Engineering offered through a cooperation of five Nordic universities awards a double degree, a Master from the core university and from the university offering the specialization track.
8. Admission requirements: Based on the ECTS credit system, universities have very similar and comparable admission requirements for graduate and postgraduate programs. A Bachelor or equivalent degree in a related science or engineering field is required for admission to a Master program. Work experience is mandatory for a few programs; personal interviews may be conducted for programs with very limited number of spots. English language capabilities have to be proven through TOEFL, IELTS or similar certification.

9. Type of program: A secondary criteria for further classification can be the nature of the program. Most programs are tailored to “regular” full-time students that complete their academic education before entering the job market. A second group of programs could be labeled “vocational” or “add-on” as the target audience includes more mature students with work experience or in a job looking to specialize further or gain additional education to improve their career options. These programs are offered as distance learning or online courses or as part-time studies.

10. Cost/tuition fees: Program cost varies between schools, countries and type and length of program. European universities typically have a two-tiered fee structure with lower tuition fees for EU students. Courses that are offered by a cooperation of universities may have varying tuition fees based on national regulations. Most universities offer few spots per program each year for international students with scholarships.

CONCLUSION
European universities offer a broad selection of graduate and postgraduate programs around sustainable energy that attract students from all over the world and with different backgrounds and motivations. Many programs have been launched within the last 5 years following the developing job market in renewable energy technology. Accordingly, the majority of programs are strongly focused on providing job and employment specific education rather than training students for academic research although most programs provide qualification for ongoing postgraduate studies.

A review of relevant programs listed on IRELP and an in-depth analysis of leading programs in Europe has been used to define segmentation criteria to establish a structured inventory of programs. Programs can be classified by key criteria, including topic, duration, credits, type of degree and delivery mode, all of which are helpful for students to choose the best program for their needs.

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11 Electrical, mechanical or civil engineering degrees and science majors from physics, mathematics are most common. Applicants with degrees in other subjects may be admitted upon review of documents, relevant work experience and/ or interview.

12 Norway and Sweden do not charge tuition fees whereas Denmark and Finland do. This may have an impact on students’ choice of university or specialization track.
ANNEX - PROGRAM EXAMPLES

Following three program examples demonstrate the variety of programs available.

1. European Master in Renewable Energy (EUREC/ 9 European universities)

The European Master in Renewable Energy is a classic Master program targeted to students that would like to gain a comprehensive education in all fields of renewable energy coupled with a specialization in a more specific area (wind, photovoltaics, grid integration, solar thermal or ocean energy). The structure of the program is based on 3 semesters awarding a total of 90 ECTS credits. During the first semester students receive a general introduction to renewable energy at their core university which also awards the Master degree after completion of all 3 semesters. The University of Zaragoza (Spain) and MINES-Paristech (France) offer first semesters in Spanish or French respectively before students choose their second semester specialization at a university in a different country. The third semester is practical with an internship in a company or research institution. It concludes with a Master thesis and presentation. The EUREC Master is designed to provide an international education in renewables. Students have to study in at least 2 different countries to complete the course. Each year, more than 50 students from more than 20 countries are admitted to the program. The European Master in Renewable Energy enables successful students to either find work in the renewable sector directly, build upon the degree with further specialization or even enter a PhD program.

Similar programs providing a general introduction and overview of all areas of renewable energy are, for example, offered by the University of Oldenburg (Germany), Northumbria University (UK) and University of Zaragoza (Spain). Some of the lectures, especially in the first semester are shared with the EUREC Master program.

2. Master Online Photovoltaics (University of Freiburg/ ISE Fraunhofer)

Since 2009, the University of Freiburg in cooperation with ISE Fraunhofer is offering the Master Online Photovoltaics, a dedicated distance learning program tailored to professionals from all over the world who have been working in a relevant field for at least one year and would like to gain additional university education. A previous degree such as a Bachelor, Master, German Diplom or FH-Diplom or equivalent foreign degree is required. The 3-year online program includes a short campus phase each semester in Freiburg for exams, lab training and networking. During the first year, students receive a general overview in renewables and photovoltaics followed by a very specific and detailed education in photovoltaics in years two and three. The curriculum is designed to provide insight into the physics, technology and system design of photovoltaics. It enables students to develop, design and optimize semiconductor devices and photovoltaic systems with respect to efficiency, cost and lifetime. The program does not require an internship as students typically already have adequate work experience. The Master thesis - often related to the current work of students -

13 Core universities include Zaragoza (Spain), MINES-Paritech (France), Oldenburg (Germany), Loughborough (UK), Hanze University (Netherlands)

14 Following specializations are available: Wind Energy (NTUA, Greece), Photovoltaics (Northumbria, UK), Grid Integration (Zaragoza, Spain), Solar Thermal (Perpignan, France) and Ocean Energy (Lisbon, Portugal)

15 MSc Prostgraduate Program in Renewable Energy

16 MSc Renewable and Sustainable Energy Technologies. 120 credits for a full Master or 60 credits for a Postgraduate Certificate (PG Cert)

17 Master Propio in Renewable Energy (also available online)
concludes the course. Successful students must have at least 300 ECTS upon graduating with the MSc in Photovoltaics, including credits from previous degrees\textsuperscript{18}.

3. Master Energy Management and Sustainability (École polytechnique fédérale de Lausanne)

Since 2011, EPFL has been offering a transdisciplinary program that differentiates between energy and energy management. A strong focus on a bottom-up approach to energy management is designed to prepare students for working across disciplines. Key pillars of the 2-year course include projects (with a tutor assigned to each project), elective subjects, human and social sciences, management of technology as well as a minor in “area and cultural studies”. The degree is awarded upon completion of at least 120 ECTS credits and a master thesis in connection with a 6-month internship in the industry. Students bring in their expertise and knowledge from prior education and work closely with individual tutors on projects and the development of their elective courses. The program differentiates itself by not exclusively focusing on the energy domain but rather integrating multiple disciplines relevant to energy management and sustainability. A strong emphasis is put on engineering, including economical, environmental, safety and social constraints to prepare students for the complexity of energy management and sustainability in a job or work situation.

A similar but scaled down program in Energy Management is offered as distance learning online program by the University of Zaragoza\textsuperscript{19}. The 60 ECTS program takes 2 years part-time study, including a Master thesis. The program stays on a more general level and also provides an overview in renewables. Energy management and auditing are key topics.

\textsuperscript{18} Following ECTS credits apply: 180 for Bachelor, 210 for German FH-Diplom and 240 fro German “Magister”

\textsuperscript{19} The Master Propio in Energy Management is dedicated to students looking for a professional career rather than in academics. The Master Propio is “job oriented” and does not qualify students of for other postgraduate study (e.g. PhD). In Spain, the Master Universitaria is more research and academics focused qualifying for PhD study.