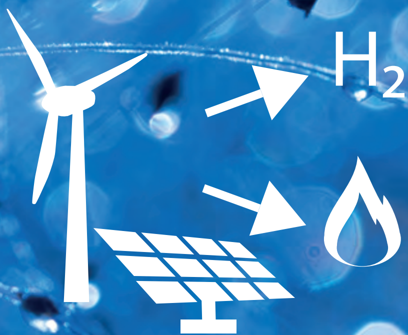
renewables academy

Online Training Programme

Green Hydrogen and Renewable Power-to-X Professional



CONTENT

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PROGRAMME SUMMARY

The share of power generation supplied by renewable energy sources is rising globally, in large part thanks to the growing numbers of PV and wind power plants. However, greenhouse gas emissions from heating and cooling, passenger and freight transport, and industrial processes remain too high. In some of these sectors, various barriers mean emissions reductions have been relatively small. Renewable Power-to-X (PtX) is seen as a promising solution with the potential to provide low-emissions energy and industrial feedstocks to sectors that have been traditionally bound to using carbon-intensive supply chains. Renewable PtX refers to the use of electricity in chemical processes and in the production of gas and fuel as well as in heating/cooling, mobility, and as energy for certain industrial applications.

The Green Hydrogen and Renewable Power-to-X Professional covers the most important technical and economic aspects of PtX applications such as hydrogen, heat pump technology, and e-mobility. Key PtX terminology, the current economic context, and recent developments of PtX are explained. Participants will learn about energy storage and artificial intelligence in the energy sector as well as about which set of parameters are used to assess the bankability of energy projects and understand a banker's perspective of risks. A calculation exercise for green hydrogen generation cost is also part of the training programme.

TARGET GROUPS

This programme is suitable for you if:

- you are planning or seeking a career transition into the renewable Power-to-X sector;
- you identify and evaluate market opportunities for green hydrogen for Power-to-X applications;
- you set the framework for Power-to-X applications; and
- you work with stakeholders in a project appraisal process.

Certified by

To benefit from this programme, participants should have a basic understanding of financial management, business administration and the wind and PV energy sectors. Additionally, experience using Excel and an interest in the hydrogen economy and in hydrogen project development are also beneficial.

LEARNING OUTCOMES

After completing these courses, participants should be able to:

- explain the purposes and potential of the Power-to-X concept;
- compare applications and technologies in energy storage;
- describe the opportunities hydrogen offers as an energy carrier for a sustainable energy future;
- explain and evaluate economic and environmental parameters of heat pump technologies and their applications;
- explain passenger car e-mobility and its implications for the distribution grid;
- harness artificial intelligence technology to improve the renewable energy sector;
- collect and prepare data required for a bankability assessment; and
- calculate relevant economic parameters of green hydrogen.

PROGRAMME STRUCTURE

MANDATORY COURSES

120 hours

- Power-to-X (PtX): Applications and Cost Developments
- Energy Storage: Application and Technology
- Heat Pumps for Heating and Cooling: Technology and Applications
- Introduction to Hydrogen
- E-mobility for Private Transport and Charging Infrastructure: An Introduction
- Co-benefits from Artificial Intelligence (AI) in RE
- RE feasibility assessment and investment valuation
- RE Project Finance

OPTIONAL COURSES

50 hours

- Introduction to Electricity
- Introduction to the Solar Resource
- Planning of Large-scale Grid-connected PV Systems
- Introduction to Wind Resource
- Wind Power Planning and Measurement

EXAM AND CERTIFICATE

2 hours

- Exam and retake covering mandatory courses
- Evaluation considering final exam and assignments
- Green Hydrogen and Renewable Power-to-X Professional Certificate
- Certificate of Attendance

Spring semester / fall semester

April / Oct			Sep / March
Introductory Optional courses	Power-to-X (PtX)	Energy Storage	E-mobility for Private Transport and Charging Infrastructure
		Heat Pumps for Heating and Cooling	Co-benefits from Artificial Intelligence in RE
Introduction Webinar 1		Introduction to Hydrogen	RE feasibility assessment and investment valuation
		Live virtual lecture 1	RE Project Finance
			Live virtual lecture 2

Introduction Webinar

INTRODUCTION TO RENAC ONLINE

first week of the semester

(1 hour)

The programme begins with an introductory orientation webinar where participants meet some RENAC staff members who explain how the Moodle platform works and its functions, and introduce the forum. The webinar also covers programme details such as activities and assignments, the exam, deadlines and scheduling. The webinar is not mandatory but participation is strongly recommended.

Live virtual lectures

Two live online lectures are part of the online training programme. These live events are not mandatory, but participation is strongly recommended. The lectures cover:

POWER-TO-X CALCULATION TOOL INTRODUCTION

midsemester

(1 hour)

POWER-TO-X (PTX) PATHWAYS

midsemester

(1 hour)

Exam and certificates

RENAC Online Academy programme final marks comprise the marks obtained on the programme's final exam (weighted 90% of total) and those from programme assignments (weighted 10% of total). The passing mark is 70%. For the exam to be computed in the overall mark, it must also have been passed (i.e. the exam mark must also be over 70%). The exam has 80 multiple choice questions and participants are given 120 minutes to complete it. To prepare, participants should work through the self-test questions in each mandatory course. Participants who score below 70% elegible to receive a certificate of attendance if they have attempted all the self-tests contained in the compulsory courses. Certificates are sent as PDF files via e-mail. Participants who do not pass the exam the first time will have the opportunity to take it again at a later date. Exam and retake dates will be announced during the introductory webinar.

Assignments and evaluation

Additionally, there are three assignments during the programme that may count as an extra 3.33% each and be added to the final score. The assignments for this programme are the following:

- Assignment A: Description of a Power-to-X project
- Assignment B: Development of supply chain of Power-to-X application
- Assignment C: Economics of Green Hydrogen - Green Hydrogen Generation Cost Calculation (GH2GCC) Tool

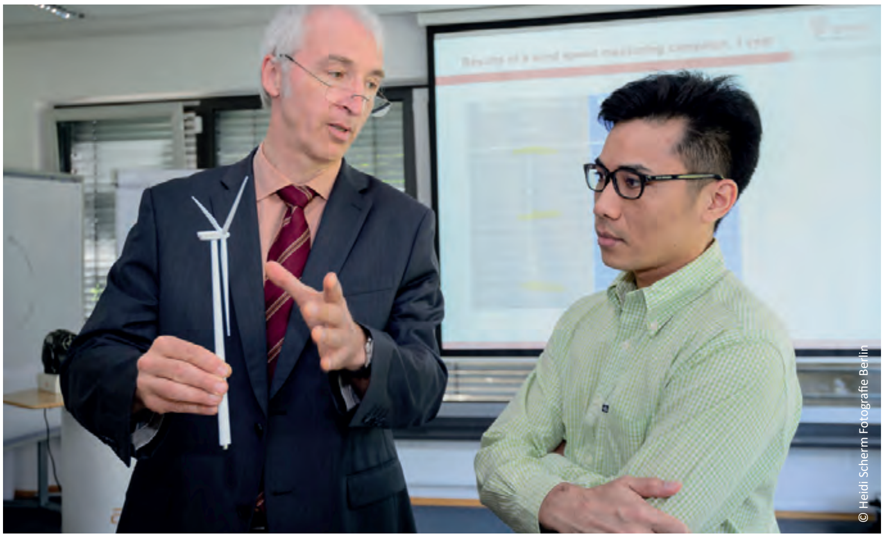
Example evaluation

Participant achieves a 75% score in the exam and passed assignments A and C during the semester, but did not have time to do assignment B.

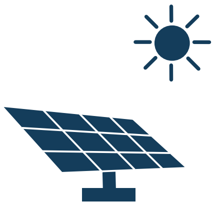
Final mark calculation

67.5+3.33+3.33 = 74.16%

(Weighted exam + A + C= 74.16%)



POWER-TO-X: APPLICATIONS AND COST DEVELOPMENTS



After completing this course, participants should be able to:

- explain the concept of sector coupling as well as the opportunities and challenges associated with it;
- compare the status quo of available technologies for sector coupling in the heating/cooling sector and in the transport sector; and
- outline the generally expected future developments regarding technology options and costs.

Content

Introduction to sector coupling

- Definition of sector coupling
- Opportunities and challenges associated with sector coupling
- RES shares in the power generation mix
- Direct versus indirect use of electricity: definition, processes and comparison of overall efficiency in different sector coupling technologies
- Electrification versus technology mix

Direct electrification in the heating and cooling sector

- Technologies and applications overview
- Electric heat pumps: technologies and main cost drivers
- Cost comparison: sector coupling versus conventional technologies and future developments
- Electric heaters: main technologies and cost parameters
- Demand profiles and flexibilisation strategies

Direct electrification in the transport sector

- Technologies and applications overview
- Passenger cars: technologies, main cost drivers and expected future developments
- Passenger cars cost comparison: sector coupling versus conventional technologies
- Passenger cars: infrastructure requirements
- Trolley trucks: technology description and infrastructure requirements
- Demand profiles and flexibilisation strategies

Indirect use of electricity

- Renewable synthetic fuels and their applications
- Production of hydrogen from renewable electricity
- Electricity generation in fuel cells
- Relevant cost drivers for renewable hydrogen production
- Production processes for synthetic methane and synthetic liquid fuels and expected cost developments

Regulatory framework

- Supporting the profitability of sector coupling and incentivising flexibility

ENERGY STORAGE – APPLICATION AND TECHNOLOGY

After completing this course, participants should be able to:

- describe the purpose and future role of energy storage systems (ESS);
- classify storage technologies;
- calculate specific costs and compare different economic aspects of ESS, and
- explain how different energy storage technologies complement each other.

Content

Introduction to energy storage

- Options for renewable energy integration
- Storage cycles
- Components of EESS
- Installed capacity and EESS technologies around the world

Terminology and definition

EEES applications according to system integration method and duration of power supply

- Overview of EESS classifications
- Class A
- Class B (short-term EESS, medium-term storage, long-term storage)
- Class C

Storage applications in different sectors

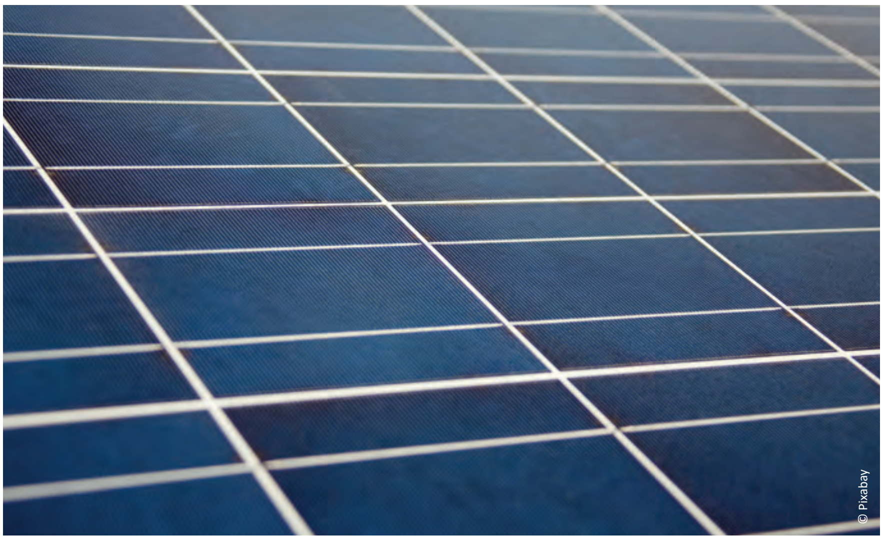
- Electro mobility
- Residential energy storage
- Industrial energy storage and uninterruptible power supply (UPS)
- Island grids

Storage technologies

- Introduction: Storage categories according to the type of energy stored
- Mechanical energy storage systems: flywheels (FES), compressed air energy storage (CAES) systems and pumped hydro storage (PHS)
- Electrical energy storage systems: super capacitors (SuperCaps) and superconductive magnetic energy storage (SMES)
- Electrochemical energy storage systems: internal storage systems and external storage
- Thermal energy storage (TES): low and high-temperature TES

Economics of energy storage systems

- EESS costs: levelised cost of storage (LCOS), life cycle cost calculation parameters, cost calculation examples and future costs and performance outlook of EESS.
- Competition among technologies: electricity-to-electricity, large versus small systems and double or multiple use of EESS



HEAT PUMPS FOR HEATING AND COOLING: TECHNOLOGY AND APPLICATIONS

After completing this course, participants should be able to:

- describe a heat pump, including its components and working cycle;
- classify different heat pump working modes;
- evaluate efficiencies to compare technologies and use cases;
- describe different heat pump technologies and their applications in terms of their performance and use in different climate zones; and
- classify refrigeration fluids according to their applications, global warming potential, and method of disposal.

Content

Definition of a heat pump, its components and its working cycle

- What is a heat pump?
- Coefficient of performance and energy efficiency ratio
- Heating and cooling

Environmental and financial performance parameters

- Operational Expenditure (OPEX) and Capital Expenditure (CAPEX)

Existing heat pump technologies and their applications

- Heat pump technologies
- Systematic overview of different heat pump system applications
- District heating and cooling systems
- Heat pumps for industrial drying and washing processes
- Heat pumps for heating water (using waste heat from a refrigeration system) and the pasteurisation process
- Photovoltaic self-consumption in combination with residential or industrial purposes

Heat pumps and their application in different climate zones

- Climate zones
- Seasonal Coefficient of Performance (SCOP) and Seasonal Energy Efficiency Ratio (SEER)
- Heat pump applications in different climate zones
- Calculating SCOP
- Calculating SEER

Refrigerant fluids

- Natural and synthetic refrigerant fluids
- The global warming potential (GWP) of refrigerant fluids
- Recovering, recycling, and environmentally friendly disposal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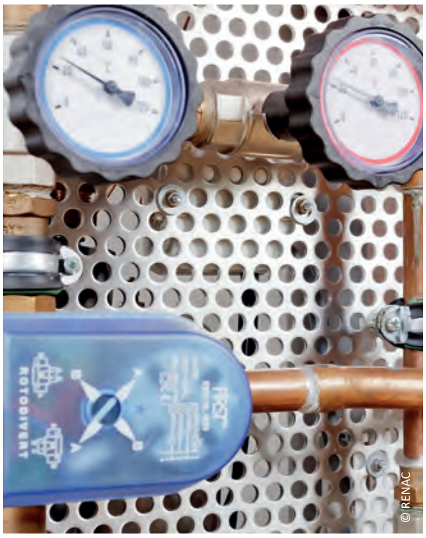
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INTRODUCTION TO HYDROGEN

After completing this course, participants should be able to:

- explain the basic components of a hydrogen-based energy system and infrastructure;
- describe the current uses of hydrogen, its production methods, and value chains;
- describe the opportunities and limitations of hydrogen as a future energy carrier and in
- developing a sustainable energy future; and
- understand the current status of hydrogen policies in the international arena.

Content

The element hydrogen (H)

- Introduction to hydrogen
- The hydrogen economy
- Global hydrogen use

Types of hydrogen applications

- Mobile applications
- Energy sector applications
- Industrial applications

Hydrogen generation and fuel cells

- Hydrogen production pathways
- Hydrogen production via electrolysis
- Types of electrolysers
- Hydrogen production with steam reforming
- Other modes of hydrogen production
- Fuel cells

Hydrogen infrastructure

- Hydrogen transport and storage
- LOHC – Liquid Organic Hydrogen Carriers

System integration / sector coupling (Power-to-X) PtX

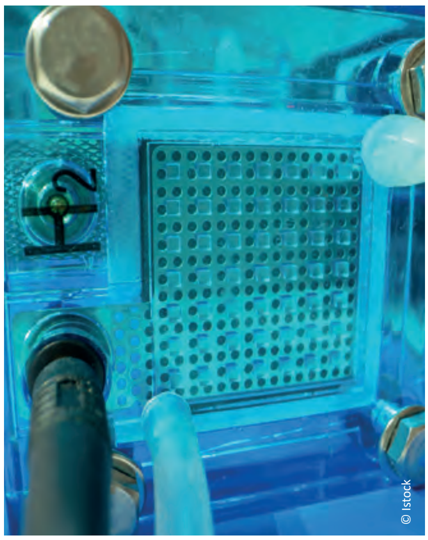
- System integration and green hydrogen

The cost of hydrogen

- The economics of hydrogen

International hydrogen strategies and roadmaps

- Hydrogen strategies and roadmaps
- The EU hydrogen strategy
- The German National Hydrogen Strategy
- The renewable hydrogen roadmap of California, USA
- The hydrogen strategy in Australia
- Cross-border project: Netherlands-Germany H2 cluster-“NorthH2”



E-MOBILITY FOR PRIVATE TRANSPORT AND CHARGING INFRASTRUCTURE

After completing this course, participants should be able to:

- justify why the transport sector must contribute to climate protection;
- name different types of electric cars and their efficiencies; and
- explain the elements of the charging infrastructure.

Content

Transport and sustainability

- The transport sector and its contribution to climate change
- Fuel combustion and the associated CO_2 emissions
- Electricity generation and the associated CO_2 emissions
- Other factors for EV sustainability

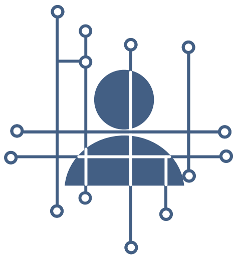
Electric vehicles for private transport

- Battery electric vehicles and plug-in hybrid electric vehicles
- Electric vehicle life cycle
- Electric vehicle efficiency

CO-BENEFITS FROM ARTIFICIAL INTELLIGENCE (AI) IN RENEWABLE ENERGY

After completing this course, participants should be able to:

- explain how AI can contribute to lowering emissions from the energy sector;
- differentiate between artificial intelligence (AI), machine learning (ML) and deep learning and the various ways that computers can "learn";
- outline use cases for AI in renewable energy (RE).



Content

Artificial intelligence and its co-benefits

- Introducing artificial intelligence (AI)
- Co-benefits of AI and the UN sustainable development goals (SDGs)
- Challenges in the power sector
- Co-benefits of AI in renewable energy (RE)

AI terminology, concepts, and algorithms

- Artificial intelligence (AI), machine learning (ML) and deep learning (DL)
- Categories of machine learning: supervised, unsupervised and reinforced learning
- Key AI/ML technical terms and concepts in brief

Assessments of AI in the literature

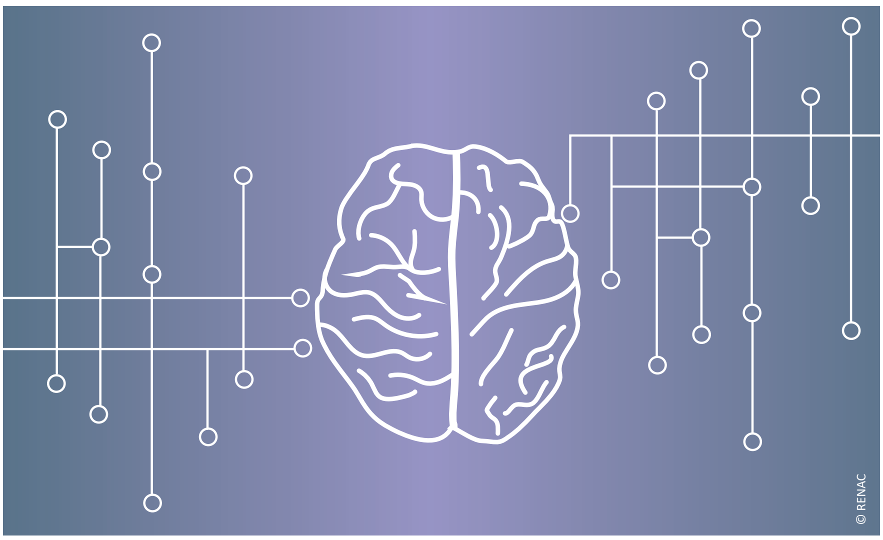
- State of the art: AI for wind power
- Artificial intelligence in an integrated energy transition
- Artificial intelligence and big data
- AI and robotics in the renewable sector

AI use cases in renewable energy (RE)

- AI applications in industry
- Electricity systems: enabling low-carbon electricity, reducing system impacts and ensuring global impact
- Transport
- Buildings and cities
- Industry: supply chains, materials and production
- AI and ICT: hidden synergies
- Artificial intelligence: current applications in the integrated energy industry

Use case identification and employment

- Applying AI: developing a comprehensive AI strategy
- Applying AI: identifying and prioritising use cases



RENEWABLE ENERGY FEASIBILITY ASSESSMENT AND INVESTMENT VALUATION

After completing this course, participants should be able to:

- explain basic financial principles including the time value of money and how to determine the cost of capital;
- understand capital budgeting tools to assess renewable energy investment attractiveness;
- calculate important economic parameters to assess the viability of a renewable energy project; and
- explain the concepts of risk and uncertainty as well as risk assessment instruments.

Content

Basic financial principles and concepts

- The time value of money: interest and future value
- The time value of money: present value and discounting
- The time value of money: interest rate components
- Discount rate and the required rate of return
- The weighted average cost of capital (WACC)

Financial performance indicators

- The basic cash flow valuation model
- Net present value (NPV)
- Rates of return: simple and modified internal rates of return (IRR, MIRR)
- Payback periods: simple and discounted payback periods
- Profitability index (PI)
- Comparing investment alternatives

RE project risk and uncertainties

- Risk assessment instruments in investment appraisal
- Sensitivity analysis
- Scenario analysis
- Simulations using Monte Carlo analysis
- Risk reduction in practice

After completing this course, participants should be able to:

- explain the different financing options for renewable energy projects in principle and the project finance option in more detail;
- perform a risk assessment for renewable energy projects;
- understand a bank's perspective of the risks related to PV, wind, and biogas plants; and
- collect the data required for a bankability assessment of a renewable energy project.

Content

Available financing options

- Balance-sheet financing
- Project financing
- Capital market financing

SPV contract negotiation

- Project investment agreements
- Operating and financing agreements

Business planning

- Estimating a project's cash outflows and inflows
- The cash flow waterfall concept
- Calculating project revenues
- Operating cost calculations and taxes payable
- From CADS to ECF
- Decommissioning costs and terminal values

Bankability assessment

- The importance of bankability assessments
- Information asymmetries and moral hazard
- Setting credit limits to prevent moral hazard
- Differentiating between risk and uncertainty
- The financial value of risk and ABC analysis
- RE project risks and mitigation measures
- RE project due diligence advisors
- Design of a "project data room"

Financial engineering

- Key financial ratios
- Calculating the LLCR, PLCR and the maximum borrowing capacity

RENAC´S ONLINE ACADEMY

The Renewables Academy (RENAC) AG is a leading international provider of training, educational, and capacity building services on renewable energy technologies and energy efficiency. Since 2008, more than 25,000 participants from over 160 countries have taken part in RENAC training courses and programmes. We are convinced that knowledge and skills are the key to the sustainable development of clean and secure energy supplies and it is our mission to provide this knowledge and skills to as many people as possible.

As part of this mission, our Online Academy was founded in 2019. Today, RENAC´s Online Academy offers over 30 short courses and programmes, with participants learning with us from the comfort of their own homes around the globe.

RENAC Online helps you:

- Boost your professional career
- Study with flexibility following your own schedule
- Learn at any time and from any location

RENAC Online staff are:

- Certified e-learning trainers
- Experienced professionals
- In direct contact with industry

Demo course

- We invite you to visit our online platform demonstration course: www.renac.de/demo-course

CERTIFIED EUROPEAN E-LEARNING MANAGER

"I really enjoyed the course and the experience was well worth the money paid. Really good value for money. Many thanks and I would no doubt be back for another course in the very near future."

Ademola Thompson, Certified Renewable Energy Project Developer: Photovoltaics, 2020

LEARNING WITH RENAC ONLINE

Learning with RENAC Online is done asynchronously in two steps. First, participants work through each course's content, and then get the opportunity to apply the newly acquired knowledge and skills, consolidating them in their minds. In practice, both steps are accomplished in several ways. Programmes also contain written assignments with feedback from RENAC that not only further reinforce learning outcomes but may also complement their exam marks.

Text and images

Courses are organised into short, instructional chapters with illustrations. Learners are guided through the material step by step.

Videos

Recorded lectures cover some of the most important topics in a visual and engaging way.

Live virtual classroom

It is recommended that participants attend live virtual lectures, which are given by RE experts. During and after lectures, participants are invited to chat about topics and issues in the live online forum.

Online Forum

A discussion forum helps to support students and foster communication between them and with RENAC. This forum is monitored by RENAC staff and experts who can provide technical assistance and discussion about course topics.

Self-tests

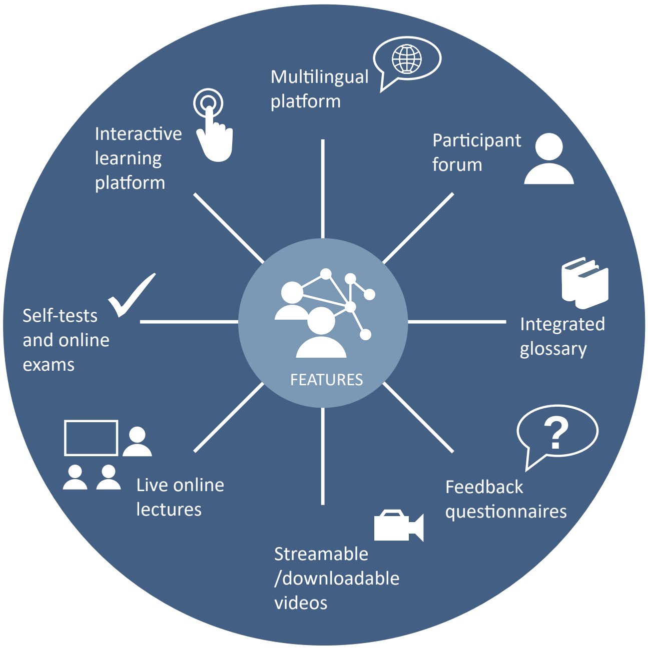
Self-tests within each course help participants assess their knowledge.

Assignments

Programmes contain written assignments with individual feedback from RENAC.

PLEASE NOTE

RENAC uses plagiarism detection software to detect its presence in submitted assignments. Plagiarism, using someone else's work or ideas as if they were your own, is unacceptable. When completing assignments, participants must acknowledge any work by others that has been included in their answers by referencing its authors.

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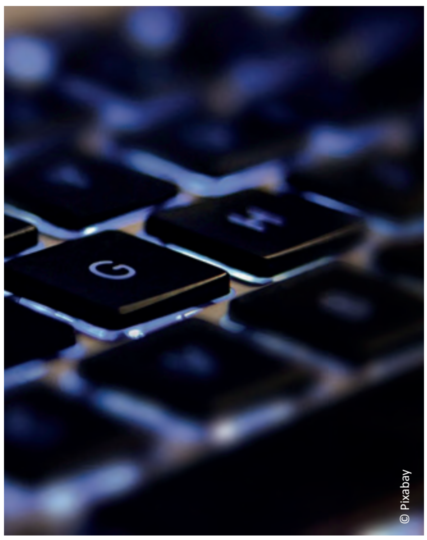
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PRACTICAL INFORMATION

START DATES

1 April / 1 October

Spring semester and fall semester each year.

RECOMMENDED STUDY TIME

About 120 hours for mandatory courses.

DURATION

3–5 weeks per course.

6 months to complete the entire programme.

ASSIGNMENTS

Programmes are designed for a continuous participation, from the beginning of the semester until the final exam, and contain short assignments. Assignments are short written essays or exercises involving other multimedia elements that need to be handed in by deadlines so they can count to improve the final grade of the exam.

TECHNICAL INFORMATION

You need to provide an email address in order to register and create your account, where you will receive course updates and feedback. You need access to a device with a reliable internet connection (at least 2 Mbit/s). This may be a mobile device, but we recommend using a computer. Live virtual lectures and orientation take place on Zoom, so you also need a headset or speakers to listen to the presentations.

REGISTRATION

You can register online at:
www.renac.de/online-academy

REGISTRATION DEADLINE

30 September / 31 March

FEE

EUR 1,850.00 including 19 % of German VAT

DISCOUNTS

Early bird 10%; group (2 or more) 5%; combination of both 15%; Alumni 10%

EARLY BIRD DISCOUNT DEADLINE

20 August / 20 February

PAYMENT METHODS

VISA, MasterCard, American Express, PayPal, or bank transfer

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Start of semester: 1 April and 1 October

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Renewables Academy Online
www.renac.de/online-academy