Renewable Energy Technologies

Basic information

Field of study Renewable Energy and Energy Management	**Didactic cycle** 2021/2022
Speciality All	**Subject code** EiPEOZS.IIi1S.cba03c048e3ff7a03756d93f3eb0db86.21
Department Faculty of Energy and Fuels	**Lecture languages** English
Study level Second-cycle (engineer) programme	**Mandatory** Obligatory
Study form Full-time studies	**Block** Major Modules
Education profile General academic	**Subject related to scientific research** Yes

Subject coordinator	Mariusz Filipowicz
Lecturer	Mariusz Filipowicz, Wojciech Goryl, Krzysztof Sornek, Rafał Figaj, Mateusz Szubel

Period Semester 1	**Examination** Exam **Activities and hours** Lecture: 30, Laboratory classes: 30, Project classes: 15	**Number of ECTS points** 7.0

Goals

C1	Making students aware of meaning of deep understanding of thermodynamic/physic bases in the process of developing correct model of the phenomena, device element or even entire energy system.
C2	Transferring the knowledge concerning functioning and operation of fundamental devices in the renewable-energy-systems, by carrying out theoretical investigations, practical exercises as well as designing process.
C3	Presenting issues of the renewable energy technology optimization, it's modern methods and barriers.
C4	Indicating the role of renewable energy technologies in environment protection issues and presenting problems related to economic aspects of RET application.

Subject learning outcomes

Code	Outcomes in terms of	Directional learning outcomes	Examination methods
Knowledge – Student knows and understands:			
W1	advanced methodologies for analyzing energy technologies based on renewable energy sources, including mathematical and numerical modeling,	EOZ2A_W01, EOZ2A_W03	Examination
W2	advanced methods of using renewable energy sources and cooperation of renewable energy technologies with energy systems.	EOZ2A_W02, EOZ2A_W05	Examination
Skills – Student can:			
U1	design and choose the essential energy machines, devices and installations,	EOZ2A_U06, EOZ2A_U08, EOZ2A_U09	Project, Report
U2	is able to apply optimization methods and solve practical technical-economical energy problems.	EOZ2A_U01, EOZ2A_U02, EOZ2A_U03, EOZ2A_U04, EOZ2A_U05, EOZ2A_U07	Project, Report
Social competences – Student is ready to:			
K1	work respecting the importance of non-technical aspects and results of the engineer's activity, including environmental impact, as well as the responsibility for decisions taken.	EOZ2A_K02	Project, Report
K2	is able to provide the public with information on state-of-the-art as well as other aspects of the engineer's activity, for example using mass media.	EOZ2A_K01	Project, Report

Programme content that ensure achieving learning outcomes for the module

Lecture materials, case studies based on processing of data obtained from studies on experimental stands being part of the teacher's research team facilities, interpretation of results of student's experiments, original and unique tutorials allowing to get familiar with advanced methods of numerical modelling and using it for optimization purposes.

Calculation of ECTS points

Activity form	Average amount of hours* needed to complete each activity form
Lecture	30
Laboratory classes	30
Project classes	15
Preparation for classes	40
Preparation of project, presentation, essay, report	40
Realization of independently performed tasks	30
Examination or Final test	2

Contact hours	5
Student workload	**Hours** 192
Workload involving teacher	**Hours** 75

* hour means 45 minutes

Study content

No.	Course content	Subject learning outcomes	Activities

1.	Lectures: 1. Introduction to solar energy: solar constant, time equation, transfer of solar radiation through the atmosphere. Introduction to mathematical theory of solar collector, basic parameters of solar collector, construction and types, components. Examples of thermal solar installations. 2. Introduction to photovoltaic, band structure of solid state, photovoltaic effect, characteristics of the solar cells, full spectrum photovoltaic systems, hybrid systems: photovoltaics+thermics, thermophotovoltaics. Photovoltaic power plants. 3. Wind energy: origin of the winds, wind power, Betz' law, basic parameters of the wind, different scale wind systems, small wind turbines, urban wind turbines, future technologies of wind energy conversion. 4. Water energy: the euler turbine equation, different scale water energy systems, turbine types, ocean energy (OTEC, tidal, wave, salinity difference, etc.), basic parameters applied for selection of the turbine type, conversion of water energy. 5. Origin of geothermal energy, geothermal energy systems, ground heat exchangers, heat pumps. 6. Biomass energy and biomass energy systems – thermal and electric energy and integration with other energy systems, the basics of solid biomass thermal decomposition theory. 7. Technologies devoted to storage and transfer, their compatibility with RES, case studies, introduction to virtual power plants. 8. Problems discussed with students during lectures – e.g.: • The environmental and social aspects of renewables, • Problems of the renewable energy systems integration, • Issues of alternative methods of the renewable energy storage, • Solutions for improvement of the renewable energy conversion efficiency; • Integration of alternative energy generation technologies with RES;	W1, W2, K1, K2	Lecture

2.	Laboratory classes. Experimental studies of selected renewable-based and renewable-related energy technologies: 1. photothermal conversion 2. photovoltaics 3. biomass thermochemical conversion 4. wind energy 5. hydroenergy 6. cogeneration, trigeneration 7. renewable-based energy storages	U1, U2, K1, K2	Laboratory classes
3.	Designing, mathematical and numerical modelling and optimizing of selected elements of devices and systems considered as part of lectures and laboratory classes.	U1, U2, K1, K2	Project classes

Course advanced

Teaching methods:

Lectures, Laboratory classes, Multimedia presentation, Discussion, E-learning, Case study, Group work method, Design thinking, Problem based learning, Project based learning, Gamification, Brainstorming, Blackboard exercises, Teaching methods and techniques used at a place where a practical placement is performed

Activities	Examination methods	Credit conditions
Lecture	Examination	Positive grade from the final exam (at least 50% of points possible)
Lab. classes	Report	Positive grade for each report and for final test (at least 50% of points possible), being prepared for each classes
Project classes	Project	Positive grade for each project report and for final test (at least 50% of points possible)

Additional info

Detailed form of tests and reports is given by the teacher during organizational classes and - if required - before each form of evaluation in frames of group or individual consultations.

Requirements and method of completing particular forms of classes

Laboratory classes:
- at most 1 absence from classes,
- positive grade for each report,
- positive grade for final test.

Project classes:
- at most one absence from classes,
- positive grade for each project report,
- positive grade for final test.

It is absolutely required to get the credit for laboratory and project classes to take the exam.
There three exam dates - first exam and ONLY two retakes.

Method of calculating the final grade

Final grade (FG) is determined on the basis of AGH regulations regarding assesment thresholds and using the following equation:
FG=0,3*E + 0,35*P + 0,35*L * R
E - exam grade
P - project classes grade
L - laboratory classes grade
R: 1 - for 1st exam, 0,9 - for 1st retake, 0,8 - for 2nd retake.

The final grade is determined to two decimal places without rounding, in accordance with the following rule depending on the numerical value: 1) from 3.00 verbal rating: sufficient (3.0) 2) from 3.21 verbal mark: plus sufficient (3.5) 3) from 3.71 verbal mark: good (4.0) 4) from 4.21 verbal mark: plus good (4.5) 5) from 4.71 verbal mark: very good (5.0).

Grades indicate that a student is able to use acquired knowledge and apply the research methods in the projects related to the design, mathematical and numerical modelling and optimization of the RES-based system (in reference to EIT OLO 5):
5,0 - apply appropriate cutting-edge research methods throughout the project,
4,5 - apply appropriate cutting-edge research methods in major part of the project,
4,0 - apply appropriate research methods in parts of the project work,
3,5 - show evidence of understanding some research methods in the field of his project work,
3,0 - show very limited evidence of knowing and understanding research methods in the field of his project,
2,0 - no evidence of the Learinig Outcomes shown.

Method and procedure for compensating for missed coursework resulting from student absence from classes

Lectures:
Before next lecture, student is obliged to master the missed lecture based on the material uploaded by the teacher on the course e-learning account and individually found scientific literature.
Laboratory classes:
One missed exercise - simply mastering the material when preparing a report with the rest of the group members (does not require confirmation of sick leave).
Two or more absences - catching up exercises /total number of absences minus one/ in frames of the other laboratory group classes (if one exists) or during extra classes. In the second case, date and form of each catching up meeting has to be consulted with teacher. Sick leave receipt required.
Less that 51% of attendance during classes disqualifies the student to get the course credit.
Project classes:
One missed exercise - no sick leave receipt required.
Two or more absences - catching up all the backlog, based on individual guidelines from the teacher. Sick leave receipt required.
Less that 51% of attendance during classes disqualifies the student to get the course credit.

Entry requirements

Student enrolling the course has to be familiar with:

- physics of energy conversion,
- simple heat balance calculations,
- bases of electrotechnics, especially methodology of scheme development and connecting simple electric circuits, including measurement apparatus (voltmeters, ammeters, different configurations of surce-receiver systems etc.),
- fundamental principles of fluid dynamics and thermodynamics;

Additionally, student enrolling the course is obliged to have the UPeL (AGH e-learning plaftorm) account. The account has to be activated not lather than just before the first classes.

Attendance requirements for particular classes, with indication whether student attendance is compulsory

LECTURES:
In frames of lectures student is getting familiar with the material presented by the teacher in form of slides presentation or practical examples, also in field form. Students have to contribute actively in lectures in case of running discussion/debate

form of classes. Lecture classes attendance is not obligatory, however it can positively influence on the final grade (additional points for active contribution, attendance lists etc).
As part of the lectures, the student becomes familiar with the material presented by the teacher in the form of slide presentations or practical examples, also in the field. Students must take active part in lectures when conducting classes in the form of discussion / debate. Participation in lectures is not obligatory, however, it can positively affect the final grade (additional points for active contributions, attendance lists, etc.). As part of the lectures, the student becomes familiar with the material presented by the teacher in the form of slide presentations or practical examples, also during field visits. Students must take active part in lectures when conducting classes in the form of discussion / debate. Participation in lectures is not obligatory, however, it can positively affect the final grade (additional points for active contributions, attendance lists, etc.).

Laboratory classes:

In frames of the laboratory classes, the student must participate in a series of practical studies using dedicated experimental stands and advanced computer software. Each classes start with short oral test (individual for each student) asessing the student's knowledge of the subject of the excercise and measurement methodology. Passing the test is a basic condition for participation in in classes. Students carry out exercises in small groups. Then they prepare the reports that have to be delivered to the teacher bofore deadline set. Laboratory classes are summarized by final test concerning the knowledge acquired throughout the whole semester. Participation in this form of classes is compulsory.

Project classes:

Students practice developing and calculating models related to information obtained through lectures and laboratories. Additionally they broaden their knowledge based on materials provided by the teacher. Then they have to prepare original projects of the selected RES-based system, inlcuding technical and economic issues of its application. Attendance in this form of classes is compulsory.

Literature

Obligatory

1. Newest scientific papers provided by the teacher or found individually by a student based on the teacher's instructions. Due to dynamic development of considered technologies, literature will be changed in each next semester. Details will be given during organizational meeting and during subsequent classes.

Optional

1. Biomass in small-scale energy applications : theory and practice / ed. by Mateusz SZUBEL, Mariusz FILIPOWICZ. — Boca Raton : Taylor & Francis, CRC Press, 2019. — XII, 348 s.. — (Energy Systems: From Design to Management).

Research and publications

Research

1. Research on the issues of biomass thermochemical treatment in small-scale energy applications.
2. Research on possibilities of using the systems combining CSR technology with other RES.

Publications

1. Air manifolds for straw-fired batch boilers – experimental and numerical methods for improvement of selected operation parameters / Mateusz SZUBEL, Mariusz FILIPOWICZ, Beata Matras, Szymon PODLASEK // Energy ; ISSN 0360-5442. — 2018 vol. 162, s. 1003–1015.
2. Analysis of selected problems of biomass combustion process in batch boilers – experimental and numerical approach / Mateusz SZUBEL // EPJ Web of Conferences ; ISSN 2101-6275. — 2016 vol. 114 art. no. 02119, s. 1–10. — Bibliogr. s. 10, Abstr.
3. Application of various 'response surface' – based algorithms in optimization of air manifolds for batch boilers / Mateusz SZUBEL, Mariusz FILIPOWICZ, Anna Mikrut // EPJ Web of Conferences ; ISSN 2101-6275. — 2019 vol. 213, art. no. 02083, s. 1–10. — Bibliogr. s. 10, Abstr.
4. Characterization of the wood combustion process based on the TG analysis, numerical modelling and measurements performed on the experimental stand / Mateusz SZUBEL, Mariusz FILIPOWICZ, Wojciech GORYL, Grzegorz BASISTA // E3S Web of Conferences; ISSN 2267-1242. — 2016 vol. 10 art. no. 00133, s. 1–8.
5. Computational fluid dynamics as a modern tool in studies of biomass-based small-scale energy devices / Mateusz SZUBEL, Maciej Kryś, Karolina PAPIS // W: Biomass in small-scale energy applications : theory and practice / ed. by Mateusz Szubel, Mariusz Filipowicz. — Boca Raton : Taylor & Francis, CRC Press, 2019. — (Energy Systems: From Design to Management). — ISBN: 978-0-367-20105-5 ; e-ISBN: 9780429286063. — S. 317–340. — Bibliogr. s. 337–340.

6. Feasibility of a small-scale hybrid dish/flat-plate solar collector system as a heat source for an absorption cooling unit / Rafał FIGAJ, Mateusz SZUBEL, Estera PRZENZAK, Mariusz FILIPOWICZ // Applied Thermal Engineering ; ISSN 1359-4311. — 2019 vol. 163 art. no. 114399, s. 1–10. — Bibliogr. s. 9–10, Abstr.
7. The numerical model of the high temperature receiver for concentrated solar radiation / Estera PRZENZAK, Mateusz SZUBEL, Mariusz FILIPOWICZ // Energy Conversion and Management ; ISSN 0196-8904. — 2016 vol. 125, s. 97–106. — Bibliogr. s. 105–106, Abstr.

Directional learning outcomes

Code	Content
EOZ2A_K01	Is aware of the need to critically assess the information received and knowledge acquired, recognizes the importance of knowledge in addressing cognitive and practical problems, in particular in the field of energy.
EOZ2A_K02	Is aware of responsibility for the tasks performed, is willing to think and act in an entrepreneurial and professional manner, is aware of compliance with the principles of professional ethics and the cultivation and dissemination of appropriate practices, as well as initiation of actions for the benefit of the social community and public interest, including the rational use of energy and provision of the national energy security.
EOZ2A_U01	Is able to use knowledge of basic sciences, thermodynamics, material science and related topics to develop physical and mathematical models of analyzed technical issues in order to solve them using advanced IT tools, crytically analyze and evaluate the solution, verify it experimentally and present information.
EOZ2A_U02	Is able to use knowledge to plan and conduct research on energy processes using various methods, including experimental ones, is able to use available software and create own computer codes for the purpose of analysis of the solution, is able to perform a critical analysis of results and prepare a synthetic compilation presenting the results of conducted research in terms of economic and environmental analysis.
EOZ2A_U03	Is able to formulate hypotheses related to the functioning and effectiveness of renewable energy systems, perform verification analysis, apply optimization methods and solve practical technical and economic problems.
EOZ2A_U04	Is able to create mathematical models of technical issues to solve them, can asses the functioning of energy systems and prepare a forecast and plan for their development at different levels of management.
EOZ2A_U05	Is able to carry out critical, from the technical, economic, environmental and social point of view - analysis of the functioning of any element of the energy system and develop a project of improvement in the construction and operation of renewable and classic energy equipment and installations.
EOZ2A_U06	Is able to develop a complete project involving machinery, equipment and energy installations, including also relevant automation, control, monitoring and process visualisation systems using a wide range of modern technical, IT and data transmission tools.
EOZ2A_U07	Is able also to assess the impact of energy systems on the global functioning of civilization, including society, natural environment, economic and social development and related issues, is able to present own point of view to a wide range of audiences, also using a foreign language and presentations illustrating advanced technical and non-technical problems in the field of energy.
EOZ2A_U08	Is able to lead a team dedicated to solving energy-related technical problems using a variety of technical and IT tools and resources.
EOZ2A_U09	Is able to plan self-learning using various forms of information acquisition, including professional publications (also in a foreign language) and to conduct self-learning by criticall analysis of the information acquired.
EOZ2A_W01	Knows and understands the phenomena described in the basic sciences, methods of their thermodynamic description and modelling in connection with the use of materials in the power industry.
EOZ2A_W02	Knows and understands basic and advanced processes occurring during the operation and functioning of machines, networks and power and electrical systems that use renewable energy sources, the importance of automation and control of their operation, the importance of proper design and selection, forecasting and planning of their development and the impact of energy technologies on the environment.
EOZ2A_W03	Knows and understands development trends in fields related to renewable energy, such as processing of energy resources, co-generation, environmental protection technologies and modern information and optimization methods that broaden the application horizon of RES.
EOZ2A_W05	Knows and understands the norms and legal regulations applied in the power industry, the concepts in the field of industrial property protection, copyrights and patent information, the basis of economics and management in renewable energy and environmental protection.