Integrated Energy Resource Planning

Basic information

Field of study Renewable Energy and Energy Management	**Didactic cycle** 2021/2022
Speciality All	**Subject code** EiPEOZS.Ili2S.4cef045b928b83f8c4125b77b2d91d86.21
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	Artur Wyrwa
Lecturer	Artur Wyrwa, Wojciech Suwała, Marcin Pluta

Period Semester 2	**Examination** Assessment **Activities and hours** Lecture: 15, Laboratory classes: 15, Project classes: 30	**Number of ECTS points** 5.0

Goals

C1	The aim of this course is to give a comprehensive understanding of the short- and long-term energy system planning.
C2	The other aim is the development of students' ability to identify short- and long-term future consequences of energy plans and decisions from an integrated perspective.

Subject learning outcomes

Code	Outcomes in terms of	Directional learning outcomes	Examination methods
Knowledge – Student knows and understands:			
W1	the steps in the development of an integrated energy resource plan.	EOZ2A_W06	Scientific paper
W2	the methods of planning the operation and development of the energy system.	EOZ2A_W03	Execution of laboratory classes, Scientific paper
Skills – Student can:			
U1	characterize energy generation technologies with the use of techno-economic parameters, is able to formulate mathematical equations for the capacity expansion as well as for unit commitment and economic dispatch problems.	EOZ2A_U04	Execution of laboratory classes, Scientific paper
U2	compare different flexibility options in the supply- and demand-side of the energy system. Is able to analyse how different demand side management strategies change electrical load profile.	EOZ2A_U04	Execution of laboratory classes, Scientific paper
U3	build energy scenario with the use of explorative and/or normative approach. Student is able to indicate costs components of electricity generation, to prepare an energy balance of the energy system considered and to estimate emission levels of air pollutants and GHG gases associated with a given energy scenario.	EOZ2A_U07	Execution of laboratory classes
U4	apply GAMS language to solve selected problems related to energy system optimization.	EOZ2A_U03	Execution of laboratory classes
Social competences – Student is ready to:			
K1	critical assessment of own results related to energy system planning.	EOZ2A_K01	Execution of laboratory classes, Scientific paper

Programme content that ensure achieving learning outcomes for the module

The content of the programme includes lectures, laboratory and project classes. Laboratory classes are split into two parts. In the first part students work on a case study using “Platform for an Integrated Energy System Analysis” – a web application offered in the Energy domain of the PLGrid infrastructure making use of supercomputers of ACC Cyfronet. In the second part of laboratory classes students will be given some assignments related to energy system planning. They will need to extend an existing GAMS code to find answers for problems given in the assignments.During project classes students work in small teams on a problem related to either short- or long-term energy system planning. The problem has to be tackled considering technical, environmental and social dimensions.

Calculation of ECTS points

Activity form	Average amount of hours* needed to complete each activity form
Lecture	15
Laboratory classes	15
Project classes	30

Preparation for classes	30
Preparation of project, presentation, essay, report	35
Student workload	**Hours** 125
Workload involving teacher	**Hours** 60

* hour means 45 minutes

Study content

No.	Course content	Subject learning outcomes	Activities
1.	Lectures: 1. Genesis of the IRP concept, main definitions, steps of IRP, supply- and demand-side management, energy services. 2. The role of energy scenarios. Main approaches in building of an energy scenario. Examples of global/regional/national energy scenarios. 3. Power system optimization modeling in GAMS. 4. Shaping load profiles. Load management. Base load, intermediate load and peak load plants, load-duration curve. Availability and capacity factor of power generation technologies. Operational constraints and flexibility options in energy system. 5. Least Cost Planning. Components of energy costs, marginal energy and capacity costs. Load shedding and value of loss of load. 6. Capacity expansion planning. Constrained optimization. Importance of constraints. 7. Power plants dispatching. Unit commitment and economic dispatch problems. Costs- vs price-based approaches. 8. Integrating intermittent renewable energy technologies within the power system.	W1, W2	Lecture

2.	The laboratory classes are divided into two parts. In the first part students, after after getting acquainted with the e-learning materials, prepare a case-based study related to a long-term power system capacity expansion planning using the Platform for an Integrated Energy System Analysis (PIESA). PIESA is a web-application for an integrated energy system analysis offered in the Energy domain of the PLGrid infrastructure making use of supercomputers of ACC Cyfronet. It consists, among others, of a bottom-up energy-economic model TIMES (generator developed by International Energy Agency). Students start their work by analyzing the technical, economic and environmental implications of the a base-case scenario. Then, they elaborate two other scenarios i.e. RES - which assumes the grow in renewable energy sources and CLIM - which assumes some actions aimed at CO2 emission reduction. In second part, students are given some assignments related to the energy system planning. They need to extend an existing GAMS codes to find answers for problems given in the assignments.	W1, U1, U3, U4, K1	Laboratory classes
3.	Students in small teams (ca. 3 students) work on a given problem related to either short- or long-term energy system planning. They need to define a problem by themselves and present it to the teacher for having his acceptance (a size and a scope of the problem needs to be adequate). The problem has to be tackled considering technical (e.g. technologies) , environmental (pollutants emissions) and social (e.g. electricity prices, external costs) dimensions. Students need to develop own code/tool they will use as analytical apparatus. Finally, students present their work in a form of a draft version of an article, meeting the requirements of the selected scientific journal.	W2, U2, U4, K1	Project classes

Course advanced

Teaching methods:

Lectures, Laboratory classes, Project assignments, E-learning, Problem based learning, Project based learning

Activities	Examination methods	Credit conditions
Lecture	Scientific paper	It is necessary to prepare a draft version of the article meeting the requirements of the selected scientific journal.
Lab. classes	Execution of laboratory classes, Scientific paper	It is necessary to prepare a draft version of the article meeting the requirements of the selected scientific journal.
Project classes	Scientific paper	It is necessary to prepare a draft version of the article meeting the requirements of the selected scientific journal.

Additional info

Lectures and projects can take the form of physical and/or online meetings. Digital learning materials will provide necessary knowledge for the first part of the laboratory clasess. The module's website is available under the address: http://home.agh.edu.pl/~awyrwa.

Requirements and method of completing particular forms of classes

In order to pass the classes it is necessary to obtain positive partial marks from the project report and final presentation (at least 3.0).

Method of calculating the final grade

Final grade is determined on the basis of AGH regulations regarding the grade thresholds and using the equation below:
FG= 0,5*L*R +0,5*P*R
L - laboratory classes grade
P - project classes grade
R: 1 - for 1st evaluation 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 tha the student in his energy plan is able to identify the short- and long-term future consequences of plans and decisions from an integrated energy-environemnt-society perspective moving towards a sustainable society (in reference to EIT OLO 1):
5,0 - is able to addresses all relevant stakeholders and is able to analyze short- and/or long-term future impacts of energy system in three main dimensions (i.e. energy sector, environment and society).
4,5 - is able to addresses all relevant stakeholders and is able to analyze short- and/or long-term future impacts of energy system in one of main dimensions.
4.0 - is able to addresses some stakeholders and is able to analyze short- and/or long-term future impacts of energy system in one of main dimensions.
3,5 - show awareness of the relations between stakeholders and is able to describe short- and/or long-term future impacts of energy system in one of main dimensions.
3,0 - show only limited awareness of the relation and is able to describe short- and/or long-term future impacts of energy system in one of main dimensions.
2,0 - no evidence of the Learinig Outcomes shown.

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

One non-attendance is allowed in obligatory classes, which requires the student to independently master the material processed at that time. In the case of a student's absence two times, the student is required to independently master the material being taught during the class and pass it in the form and date specified by the teacher (latest in the last week of the course). A student who, without justification, missed more than two compulsory classes may not be clasified.

Entry requirements

It is recommended to acquire basic knowledge about energy system modeling and GAMS language by participating in relevant courses prior to this module or by studying the learning material on the module website.

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

Lectures: students attendance is highly recommended but not mandatory. The material of the lectures is performed in the order listed in the syllabus. Students should ask questions and clarify doubts on an ongoing basis. Audiovisual registration of the lecture requires the permission of the lecturer.
Project classes: students attendance is compulsory.
Laboratory classes: students attendance is compulsory.

Literature

Obligatory

1. Swisher J. N. , Jannuzzi G. M., Redlinger R. Y. "Tools and Methods for Integrated Resource Planning: Improving Energy Efficiency and Protecting the Environment", UNEP, Riso Lab., 1997
2. Mielczarski W. "Energy Systems & Markets". Association of Polish Electrical Engineers, Division Łódź, 2018.
3. Soroudi A. "Power System Optimization Modeling in GAMS". Springer International Publishing AG, 2017.

Optional

1. Wyrwa A. "Power System Development: Integrated Assessment Modelling". LAP LAMBERT Academic Publishing. 2010.

Research and publications

Research

1. Planning the operation and the development of energy systems.

Publications

1. Pluta, M.; Wyrwa, A.; Suwała, W.; Zyśk, J.; Raczyński, M.; Tokarski, S.(2020): A Generalized Unit Commitment and Economic Dispatch Approach for Analysing the Polish Power System under High Renewable Penetration. Energies, (13), 1952. DOI:10.3390/en13081952.
2. Wyrwa A. (2015): An optimization platform for Poland's power sector considering air pollution and health effects. Environmental Modelling & Software (74), p. 227-237. DOI:10.1016/j.envsoft.2015.04.017.
3. Gawlik L., Szurlej A., Wyrwa A. (2015): The impact of the long-term EU target for renewables on the structure of electricity production in Poland. Energy (92), p. 172–178. DOI:10.1016/j.energy.2015.05.066.
4. Wyrwa A., Szurlej A., Gawlik L., Suwala W. (2015): Energy scenarios for Poland a comparison of PRIMES and TIMES PL modeling results. Journal of Power Technologies (95), p. 100-106. Available online.
5. Wyrwa A., Suwała W. "Prospects for the use of SMR and IGCC technologies for power generation in Poland." W: E3S Web of Conferences 22 (2017).
6. Suwała W., Wyrwa A. i Pluta M. "Near future of Polish energy system – COP21 and BAT conclusions." W: E3S Web of Conferences 14 (2017).

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_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_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_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_W06	Knows and understands the general principles for developing individual entrepreneurship, including: principles of business plan development and business management, economics and management in the energy sector and environmental protection.