Energy Transition MSc

Curriculum

Content

SUT - The list of available courses:

	Course	ECTS	Type	Field	Pedagogy
1.	Business presentations	3	Obligatory	Business/Behavioral	AL/I
2.	Financial Engineering in Energy Sector	2	Obligatory	Business	AL/C
3.	Heat and mass transport in modern energy technologies	5	Obligatory	Expert	C/AL
4.	Mathematical and numerical modeling of energy systems	4	Obligatory	Expert	C/AL
5.	Environmental impact evaluation in full life cycle	3	Obligatory	Expert	AL/CT
6.	New generation alternative fuels	3	Obligatory	Expert	C/AL
7.	Gasification and pyrolysis	2	Obligatory	Expert	C/AL
8.	Review of renewable and conventional energy technologies	3	Obligatory	Expert/Business	C/AL
9.	Modern Boilers	4	Obligatory	Expert	C/AL
10.	Challenge based project	5	Obligatory	Expert/Business /Behavioral	CH/PBL
11.	Applied mathematics in modeling of energy processes	4	Obligatory	Expert	C/AL
12.	Project management	3	Obligatory	Business/Behavioral	PBL
13.	Clean combustion technologies	5	Obligatory	Expert	AL
14.	Business planning	3	Obligatory	Business/Behavioral	PBL
15.	Energy transition planning and implementation	3	Obligatory	Expert	AL/CT
16.	Energy storage for sustainable energy systems	3	Obligatory	Expert	AL/CT
17.	Waste to Energy	2	Obligatory	Expert	C/AL/CT
18.	Circular economy	1	Obligatory	Expert	AL/CT
19.	Energy policy and world energy sources/Energy economics	2	ELECTIVE	Expert	E/AL/CT
20.	Air quality impact assessment	2	ELECTIVE	Expert	C/AL
21.	Smart heating grids	2	ELECTIVE	Expert	AL/CT
22.	Industrial internship	8	Obligatory	Expert/Business	PBL

C – Classic, AL – Active learning, CT – Case teaching, PBL – Project Based learning, CH – Challenge driven, E – e-learning,

AGH - The list of available courses:

	Course	ECTS	Type	Field	Pedagogy
1.	Gasification	5	Obligatory	Expert	AL/I/PBL
2.	Environmental Protection in Energy Sector	3	Obligatory	Expert	AL/C
3.	Computer modelling of technological processes	2	Obligatory	Expert	C/AL
4.	Advanced coal technologies	4	Obligatory	Expert	C/AL./CT
5.	Business planning in energy sector	5	Obligatory	Business/Behavioral	AL/I
6.	Unconventional Hydrocarbons	2	Obligatory	Expert	C/AL
7.	Chemical reactors	4	Obligatory	Expert	C/AL
8.	Chemistry of coal	2	Obligatory	Expert	C/AL
9.	Students Research Group	4	ELECTIVE	Expert	C/AL
10.	Intellectual property rights	2	ELECTIVE	Expert/Business	C
11.	Planning and forecasting in energy sector	4	ELECTIVE	Expert	C/AL
12.	Sustainable energy development	3	Obligatory	Business/Behavioral	C/AL
13.	Heat and mass transfer processes in energy sector	5	Obligatory	Expert	C/AL
14.	Biomass in Energy Applications	3	Obligatory	Business/Behavioral	C/AL
15.	Energy policy	3	ELECTIVE	Expert	C
16.	Modern environmental analytics	3	ELECTIVE	Expert	C/AL
17.	Mathematical modeling	4	ELECTIVE	Expert	C
18.	Catalysis in fuel industry and air pollution control	5	Obligatory	Expert	AL/CT
19.	Biotechnology	2	Obligatory	Expert	C/AL
20.	Fluidization and Solid-Gas Systems	4	Obligatory	Expert	C/AL
21.	Carbon dioxide mitigation technologies	2	Obligatory	Expert	C/AL/CT
22.	Advanced liquid biofuels	3	Obligatory	Expert	C/AL
23.	Renewable Energy	3	Obligatory	Expert	C/AL
24.	Fuel Cells and Hydrogen Production	3	ELECTIVE	Expert	AL/CT/E
25.	Low emission combustion	3	ELECTIVE	Expert	C/AL
26.	Ceramic materials for energy industry	3	ELECTIVE	Expert	C/AL
27.	CFD modeling with ANSYS Fluent	3	ELECTIVE	Expert	C/AL
28.	Radioactive elements in power industry and soil pollution control	3	ELECTIVE	Expert	C/AL
29.	Eco-Innovation in Industry	5	ELECTIVE	Expert/Business /Behavioral	AL./E
30.	Smart heating grids	3	ELECTIVE	Expert	AL/CT/E
31.	Industrial internship	6	Obligatory	Expert	PBL/I

C – Classic, AL – Active learning, CT – Case teaching, PBL – Project Based learning, CH – Challenge driven, E – e-learning,

IST - The list of available courses:

	Course	ECTS	Type
For all Specializations:			
1.	Decision Support Models	6	Common
2.	Economics and Energy Markets	6	
3.	Energy Management	4,5	
4.	Project in Energy Eng. and Management I	6	Dissertations
5.	Project in Energy Eng. and Management II	6	
6.	Master thesis	30	
7.	Project Risk Evaluation and Management	6	Free
8.	Ambient Intelligence	7,5	
9.	Embedded Computational Systems	6	
10.	Engineering Economics	6	
11.	Commercial & Strategic Management	6	
12.	Marketing Management	6	
13.	Technology Based Entrepreneurship	7,5	
14.	Seminars on Innovation and Sustainable Development	4,5	
15.	Environmental and Sustainability Challenges in Engineering	1,5	
16.	Environmental Impacts	6	
17.	Natural & Technological Risks	4,5	
18.	Industrial Safety and Health	6	
19.	Public Policies for Energy	6	
20.	Corporate Control and Corporate Governance	6	
21.	Industrial Organization	6	
For a specialization in Fuels:			
22.	Catalysis and Catalytic Processes	6	Harmonization (0-24 ECTS depending on your BSc; check with MEGE coordinator)
23.	Chemical and Biological Process Engineering	4,5	
24.	Thermodynamics and Transport Phenomena	6	
25.	Biofuels	6	Specialized (24-36 ECTS)
26.	Combustion	6	
27.	Alternative Fuels	6	
28.	Chemical Engineering Laboratory III	3	
29.	Process Synthesis and Integration	6	
30.	Oil and Gas	6	
31.	Stochastic Modelling of Oil Reservoirs	6	
32.	Waste to Energy	6	
33.	Air Pollution and Treatment of Gaseous Effluents	4,5	Complementary (6-18 ECTS)
34.	Production and Demand of Electric Energy	6	
35.	Industrial Processes Automation	6	
36.	Engineering Management Projects	6	
37.	Project Appraisal	6	
38.	Logistic Management and Operations	6	
For a specialization in Energy Conversion:			
39.	Combustion	6	Harmonization (0-24 ECTS depending on your BSc; check with MEGE coordinator)
40.	Electrical and Servicing Systems	7,5	
41.	Production and Demand of Electrical Energy	6	Specialized (24-36 ECTS)
42.	Electrochemistry and Energy	6	
43.	Nuclear Reactors	6	

44.	Renewable Sources and Distributed Power Generation	6	
45.	Internal Combustion Engines	6	
46.	Turbomachinery	6	
47.	Thermal Equipments	6	
48.	Electrical Machines	6	
49.	Hydropower	6	
50.	Air-conditioning in Buildings	6	Complementary (6-18 ECTS)
51.	Industrial Refrigeration	4,5	
52.	Energy in Transports	4,5	
53.	Propulsion	6	
54.	Computational Fluid Mechanics	6	
55.	Industrial Processes Automation	6	
56.	Waste to Energy	6	
57.	Air Pollution and Treatment of Gaseous Effluents	4,5	
58.	Engineering Management Projects	6	
59.	Project Appraisal	6	
60.	Logistic Management and Operations	6	
61.	Energy Services	6	
For a specialization in Renewable Energy:			
62.	Combustion	6	Harmonization (0-24 ECTS depending on your BSc; check with MEGE co-ordinator)
63.	Electrical and Servicing Systems	7,5	
64.	Renewable Energies	4,5	Specialized (24-36 ECTS)
65.	Renewable Sources and Distributed Power Generation	6	
66.	Biofuels	6	
67.	Electrical Machines	6	
68.	Power System Network Analysis	6	
69.	Turbomachinery	6	
70.	Electrochemistry and Energy	6	
71.	Hydropower	6	
72.	Photovoltaic Solar Energy	6	
73.	Solar Thermal Energy	6	
74.	Marine Current & Tidal Energy	6	
75.	Wave Energy	6	
76.	Offshore Wind Energy	6	
77.	Energy Storage	6	
78.	Hydromineral and Geothermal Resources	6	
79.	Production and Demand of Electric Energy	6	Complementary (6-18 ECTS)
80.	Air Pollution and Treatment of Gaseous Effluents	4,5	
81.	Power Electronics for Renewable Energy	6	
82.	Industrial Processes Automation	6	
83.	Waste to Energy	6	
84.	Engineering Management Projects	6	
85.	Project Appraisal	6	
86.	Logistic Management and Operations	6	
87.	Energy Services	6	

Additional activities

- PRINCE 2 management course (1st year)
- Study visits in industrial partners - total number 12 (1st year)
- Workshop on art of presentation and exerting influence (1st year)
- Workshop on design thinking (1st year)
- Workshop on problem solving (1st year)
- Workshop on leadership and teamwork (1st year)
- Teambuilding open space activities (1st year)
- Course Entrepreneur in a Week (Catholica Business School Lisbon) (2nd year)

Descriptions - SUT

1. Business presentations

The course is designed in order present this importance of socio economic factors to secure success of projects by gaining the acceptance of different stakeholders groups. Engineers and professionals are sometimes underestimating this kind of issues what could end with the failure of projects.

How the course is conducted

In theoretical part students will get the basic knowledge on the importance of socio economic aspects of decision making process which will be illustrated with numerous examples. Scope part of the classes will be conducted in Harvard Style Case teaching. In practical part students prepare TED style presentations on selected topics related to socio economic issues. It is organized in a style of competition. The presentations are recorded and discussed with tutor. Additionally students take part in projects related to develop short movies used to make the influence on general public in order to gain the social acceptance.

Learning outcomes

After the course students will be aware of importance of socio-economic factors for engineering projects emphasizing complexity of decision making process and different perspectives that should be taken into account. They would improve skills of making the influence and preparing different forms of presentations and using proper arguments.

2. Financial Engineering in Energy Sector

This course is oriented on transfer of knowledge and development of skills know in the field of financial analysis of investments in tangible assets in the energy sector. The teaching methods consist of traditional lectures, recitations and active teaching methods in the form of case teaching. The course covers the following general topics: capital and possibilities of its allocation investment projects - goals and risk analysis, phases and stages of project development path, role of prefeasibility and feasibility studies, cash flow and its components; static an dynamic indices of financial and economic effectiveness; sensitivity analysis; microeconomic, macroeconomic and legal conditions of profitability of projects in energy and environmental protection sectors and more.

How the course is conducted

The course is conducted in active learning manner. There will be discussed examples of investment projects. During the case study students participate in a hands-on training on financial analysis using a spread sheet software. They also discuss development of sample projects, performing financial projections, calculation of cash flow and profitability indices.

Learning outcomes

After the course students will understand principles and rules of the analysis as well as they will able to perform simple feasibility study of an investment project.

3. Heat and mass transport in modern energy technologies

Heat and mass transfer is a crucial mechanism of energy and mass transformation in any energy-related processes. As the bachelor level courses concentrate on basic aspects of this subject, the aim of this course is to deepen the knowledge. Both in-depth analysis of the involved phenomena and the application of advanced mathematical techniques will be addressed. Special stress will be given on the simplifications introduced in the course of the formulation of the problems at hand and the applicability of the derived models. The teaching methods consist of traditional lectures, recitations and active teaching methods in the form of what-if analysis. Students will solve practical problems using computer applications. The course will cover advanced methods of solving transient heat conduction both analytical and numerical based on finite volume method, melting and freezing. Fins of arbitrary shape, convection with phase change, diffusion including equimolar and in the presence of inert. Simultaneous heat and mass transfer. Advanced heat radiation in enclosures filled with transparent and optically active gases.

How the course is conducted

The course is conducted in an active learning manner. The students will solve practical, industry-based examples. The problems solved will include variant and sensitivity analysis to see the influence of unavoidable errors in the input data onto the results.

Learning outcomes

As a result of the course, the students will have the ability to formulate and solving heat and mass transfer problems frequently arising in the energy sector. They will also be acquainted with basic computational software, useful in engineering calculations of transfer problems.

4. Mathematical and numerical modeling of energy systems

Contemporary engineering is based on computer simulations. The danger behind using the available off the shelf software is the treatment of its interior as a black box.

Typically, the software gives the user much freedom in selecting numerical procedures and submodels. The course, building step by step the knowledge of the students of the elementary numerical procedure will finally lead to the development of a finite element code addressing all the mind bends behind the numerics. Two parallel teaching streams will be executed: lecture supported with numerous examples and project, where the students will, under the guidance of the instructor develop codes implementing the procedures discussed in the lecture theatre.

How the course is conducted

The course is conducted in an active learning manner. Using MatLab, the students will develop stepwise their own finite element code able to solve heat conduction problems in arbitrary 2D geometry. The developed code will use as pre- and post-processor the ANSYS package.

Learning outcomes

As a result of the course, will have a good knowledge of MatLab, a very strong higher-order programming language. They will be exposed to ANSYS package and know the interior of finite element codes, the available solution strategies, and treatment of boundary conditions.

5. Environmental impact evaluation in full life cycle

The course consist of two parts: Life Cycle Analysis and The thematic scope of part 1 includes the introduction to environmental analysis, using the LCA (Life Cycle Analysis) methodology, the presentation of various environmental assessment methodologies such as CML, ReCiPe, EcoIndicator 99, IMPACT + etc., economic assessment methodologies like CBA (Cost Benefit Analysis), and social analyses, including issues related to the monetization of goods. The tools for environmental assessments such as SIMA Pro, Gabi or OpenLCA are presented. In addition, issues related to the use of these analyses and legal norms related to environmental management is presented.

The thematic scope of part 2 covers issues related to the use of exergy analysis for the assessment of ecological effects. Generally, the student will receive knowledge of the use of advanced thermodynamics tools to assess the effectiveness of natural resources management. The main tools discussed during the lecture include: calculus of cumulative consumption of exergy (a tool allowing for exergy analyses in the global balance sheet), thermo-ecological cost (TEC) being the original method using exergy analysis for ecological assessments in the full life cycle. In addition, issues related to exergy applications for economic assessment and the algorithm of direct and induced exergy losses is discussed.

Way of conducting the course

The course consists of lecture where the background knowledge is delivered. Lectures are conducted in interactive way with active participation of students (FAQ model, debate, discussion, brainstorming sessions etc.) where students take part in the teaching process by elaborating key problems of EIA. Additionally case teaching sessions in Harvard style are.

Learning outcomes

The course provides students with an updated knowledge on environmental impact analysis including LCA and exergy analysis and introduce 2 case study as a summary of part of lecture. This course is designed to give the skills and abilities to justify the need of LCA and advanced exergy analysis using specific examples from various technological options, from legal, environmental and technological points of view.

6. New generation alternative fuels

This course is oriented on gaining skills in assessment and utilization of new generations alternative fuels, which usage can lead to ecological and efficient energy production from renewable energy sources. The course consists of interactive lectures, seminar and project classes, during which students will be encouraged to take part in the discussion to find the best solution for a given issue. The course covers the following general topics: production and utilization of new generation alternative fuels, co-combustion of fossil and alternative fuels, technologies for efficient and economical energy production, the ecological impact of different technologies of energy production.

How the course is conducted

The lecture is conducted in an active learning manner, industry-based examples of different technologies, used in the power industry, are given. During project and seminar students work in teams and find new solutions for the posed issues, results are presented and assessed by the group in open discussion. Every team is given a problem to solve, based on the actual state of the art the most efficient and economically justified solution should be proposed in the form of report and presentation. Students are encouraged to asses each other findings and propose their own solutions.

Learning outcomes

The course main goal is to gain skills for proper evaluation, selection and utilization of new generation alternative fuel-based energy production technologies. Additionally, students learn to cooperate in groups, present their findings for a wider audience and take part in a constructive discussion.

7. Gasification and pyrolysis

The aim of the course is to deliver knowledge on the gasification and pyrolysis processes. Basic and state of the art technologies are also introduced and discussed. The course gives a detailed overview of feedstocks, processes, as well as gasification and pyrolysis products processing and further use. Modeling and analysis of gasification process are the important skills the Students develop.

Way of conducting the course

The course is divided into two parts: lecture and project. In the lecture part presentations covering the course material are given in an interactive manner. The presentations are made available to the Students. In the project part Students are first thought how to use an advanced opensource thermochemical software, and then realize their own projects in a ‘learning by doing’ manner. The projects develop modeling and programming skills, and improve the overall understanding of the processes.

The learning outcomes

Students will understand the elementary processes occurring during gasification and pyrolysis. They will acquire knowledge on available technologies and will understand their advantages and disadvantages. Students will also be able to evaluate important process parameters and will develop skills needed to simulate the process by means of thermochemical software.

8. Review of renewable and conventional energy technologies

he module presents wide variety of power generation technologies in the context of global energy consumption, the development of the electricity generation industry and the economics involved in this sector. A series of chapters are each devoted to assessing the environmental and economic impact of a single technology, including conventional technologies, nuclear and renewable (such as solar, wind and hydropower). The technologies are presented in an easily digestible form.

How the course is conducted

The project is organized in a form of study visits in different companies from energy sector. Study visits are organized by university with assistance of academic staff and company.

Study visits gives students opportunity gain information about modern industrial solutions and provide examples of principles and good practice that can be used to develop a high quality industrial system. This is a chance to visit innovative companies and meet with experts.

The list of companies include: lignite mine, lignite power plant, innovative small-scale boiler company, waste to energy company, hard coal mine, boiler design company, municipal waste incineration plant, fossil fuel circular fluidized bed installation power plant, pumped-storage power plant, combustion technologies research institute.

During the study visits students can make contact with employers in places where they can have an interesting internship or even it could be the starting point of long-term cooperation.

After visits students should prepare detailed reports containing information about visited installations together with additional overarching information about the whole sector including technical and economic approach. Additionally self-assessment of knowledge gained and conclusions should be included as well.

The course is conducted in cooperation with industrial partners.

Learning outcomes

The review of modern energy installations is focused on vast presentation of real industrial solutions in power generation, mining, boiler construction as research in energy field. The module is designed as a blend of professional knowledge in engineering, economics, management.

9. Modern boilers

The course is devoted to modern boilers (steam generators) in clean coal and alternative fuels power plants. The students will be given a comprehensive information ranging from very basics of combustion and heat transfer theories, through designs of respective low emission power boilers to finally principles of safe and reliable boiler operation. The teaching methods consist of traditional lectures and project in the form of practical exercises in calculations and design of boilers. The course covers the following general topics: Theory of modern, low-emission power boilers and auxiliary devices, fuel properties, basics of combustion and heat transfer, basic principles of primary and secondary methods of NOx reduction, principles of steam generation, design of furnaces: pulverized, fluidized, stokers and boiler auxiliary devices, basic calculation procedures for boilers, operation and modernization of power boilers and more.

How the course is conducted

The course is conducted in active learning manner. It is divided into lectures and project. Lectures are conducted in an interactive way with use of audiovisual tools. During the lecture problem questions/topics are raised, students take part in the discussion, trying to find solution/answers, assess existing solutions. Project is focused on practical exercise in calculations and design of boilers: Calculations of boiler mass and energy balance, thermal efficiency, boilers losses and heat transfer in boiler heating surfaces.

Learning outcomes

After the course students will understand principles of boilers operations as well as they will able to perform simple calculations for boiler designing. An emphasis will be put on large, high-capacity power boilers as they are commonly used in modern fossil fuel power plants. The technologies tackled will comprise pulverized fuel boilers, fluidized bed boilers as well as stoker boilers.

10. Challenge based project

Students are set real-world challenges by our industrial partners, which enhance both problem-solving skills and awareness of all the technological, environmental and economic factors involved in the decision-making process, and how they interact together.

How the course is conducted

The module is designed in challenge driven education style with elements of project based learning.

The whole group of students receive the common challenge. During first classes the challenge is detailed discussed and the KPIs are established. Then the whole group is divided in to working groups (teams) and the leaders are nominated together with the leader of the whole group (project manager).

Teams are solving the same problem independently. Finally the challenge solution is delivered by all teams and is compared with each other. In addition all teams should deliver SWOT analysis and feasibility study. The pitches on elaborated solutions is delivered by all teams. This makes the internal competition between teams. The comparison is made on the basis of defined previously KPIs. Finally the whole group is creating the common report with clearly indicated responsibility parts. The common conclusions and executive summary is crated on the basin of contribution of all teams and finally delivered by project manager.

The solution relevant to the challenge should be assessed valued to all relevant stakeholders.

The course is conducted in cooperation with industrial partners.

Learning outcomes

This module is designed in a form of a project conducted by teams under the leadership of project management and is focused on solving the real program (challenge). The challenge is always related to the issue which is important to the industry, society and economy. The main objective is to deepen the making value judgments skills and the knowledge already gained in other modules of the program, shape the multidimensional thinking taking into account technological, economic, environmental and social issues and implement analytic skills, making value judgments together with the art of presentation, discussion and shaping teamwork skills. The module improves skills in gathering information in a real life situations on needs to be covered and problems to be solved.

11. Applied mathematics in modeling of energy processes

To provide students with basic methods of optimization and solving of differential equations encountered in analysis of engineering problems. Moreover students are informed about probability and mathematical statistics, theory and methods of estimation as well as processing of measurements results and improving their likelihood.

How the course is conducted

Lecture; Design variables, objective function, equality constrains, classification of the optimization problems. Linear programming. Minimization of function dependent on one variable. Minimization of function dependent on many variables without and with constrains. Fundamentals of genetic and evolutionary algorithms. Lectures are conducted in an interactive way with use of audiovisual tools. During the lecture problem questions/topics are raised, students take part in the discussion and brainstorms, trying to find solution/answers, assess existing solutions as well as develop critical thinking. Students are encouraged to participate in discussions which are moderated by the tutor. Students will be able to assess the dynamic nature of complex systems and change over time. They will be able to apply the tools and concepts of system dynamics and systems thinking in their present lives.

Computer laboratory; Projects: problem formulation and minimization of function dependent on one design variable, problem formulation and linear programming, problem formulation and solution of set of two differential equations

Learning outcomes

Estimation of probability distribution parameters. Determination of confidence interval of expected value and variance. Improving of measurements confidence applying coordination method.

12. Project management

The aim of the course is to skills and competencies relevant to management in business sector shaping teamwork and leadership skills. Module provides knowledge and core methodologies in the field of project management and provides the real experience in leadership and teamwork. The course is designed to provide an understanding of the particular issues encountered in planning projects and to offer students methods, techniques and ‚hands-on' experience in dealing with them. Module make students to understand how leadership practice could be applied but also that it has depth and is grounded in higher education research, business and value creation. The course is connected with delivered in Energy Transition program additional course of PRINCE2.

Way of conducting the course

Project management is organized in Learning-by-doing/Project-based learning manner. Students receive the lecture classes on principles of project management and in parallel they are involved in practical task – organization of the Environmental Protection and Energy (EPAE) Conference in Silesian University of Technology. Project is carried out in Project Based Learning manner. Students are divided in groups with elected leader – project manager. The whole project is organized in a way of a real enterprises with positions of CEO, manager etc. Students are creating all necessary documentation and perform all activities on the basis of project management rules. The project is kept in learning by doing manner – students are performing real actions in real world. The main goal is to organize the scientific conference for young scientists form different locations all over Europe. Students should deliver the full report on the performance containing description of KPIs and its fulfilment, description of all activities, executive summary and conclusions.

This course is performed in cooperation with the experts from Institute for Chemical Processing of Coal, leading R&D institution developing pilot clean coal technologies who share their experience in managing a high-risk innovative projects.

The course is conducted in cooperation with industrial partners.

The learning outcomes

After the course students will be able to define the role that projects and project management play in accomplishing the company's strategic objectives, taking into account the various types of organizations such as functional, matrix, and project structures. They will know how to assess major schedule, cost, and performance risk elements and understand the approach for managing risks using qualitative as well as quantitative techniques. Students will gain the practice how to act in real environment taking different roles.

13. Clean combustion technologies

General description

The course is devoted to modern combustion technologies in clean coal and alternative fuels power plants. The students will be given a set of information on existing and emerging technologies in various industries ranging from low capacity furnaces to combustion systems used in waste incinerators and power plants. Practical examples of real combustion facilities will be given so as students could assess their pros and cons. The course covers the following general topics: basics of modern thermal cycle equipped with combustion heat source, low-emission solid, liquid and gas fired furnaces, flue gas cleaning technologies and more.

How the course is conducted

The course is conducted in a way that student interact with each other under guidance of the lecturer. It is divided into lectures and project part. Lectures are conducted in an interactive way with use of audiovisual tools. During the lecture problem questions/topics are raised, students take part in the discussion, trying to find solution/answers, assess existing solutions. Project is focused on practical exercise in calculations and understanding of issues connected with modern combustion systems including: fuel preparation, handling and treatment, furnaces, ash and combustion by-products handling and utilization.

Learning outcomes

After the course students will understand principles of modern combustion system as well as they will able to perform simple calculations on combustion stoichiometry. They will be able to asses the suitability of a given combustion technology for a given fuel.

14. Business planning

The module makes students to use in a systematic way business skills to recognize, assess, develop business opportunities in relation to all dimensions covered in the project (market, customer, competition, environment, human and material resources)

How is it conducted?

Business planning is organized in Learning by doing manner. Students receive the introductory classes on principles of business planning and supporting materials including samples and templates of business plans. Then are asked to create business ideas for startups in energy or related sector. In next step students are working on the business plan containing all necessary parts. During this activity the support from teacher is secured in "on demand" manner. Next step is preparation of business pitch. Then students are supposed to produce the final version of business plan and deliver the business pitch to business creation jury. The jury consist of real business creation staff of venture capital organization. This part is performed in cooperation with Innoenergy business creation staff, who helps in assessing the idea, business plan and business pitch quality.

The course is conducted in cooperation with business partners.

The learning outcomes

The course will gives students the skills to conduct a feasibility analysis, identify financial requirements, and complete all aspects of the business plan from executive summary to operations and company structure. Additionally the course will shape the presentation skills necessary to defend the business ideas and give them experience in delivering business pitches.

15. Energy transition planning and implementation

This module covers the thorough aspects of energy transition issues, where the need of decommissioning (mostly fossil fuels base fleet) and technology transition (D&TT), examples of successful D&TT strategies of EU and world, EU existing coal regions with its opportunities and challenges for successful energy transformation; are described. Apart from technological issues, also non – technical barriers for energy transition planning and implementation (labour market, educational and job transitions) and potential financial support mechanisms for energy transition are discussed. As world is facing the need of the global transformation of its energy systems, not only EU should be regarded but also Africa and Asia should be taken into account when thinking of challenging potential job-market for energy transition graduates and specialists.

How the course is conducted

The course consists of two parts and is conducted in active learning manner. First part is a lecture giving examples of energy transition planning and implementation in the sectors of energy and fuels, transport and residential. The second part is problem-based-learning class making use of InnoEnergy cleanalternative.eu e-learning platform enabling to solve the case study "Coal regions in transition" devoted to the technology transition example of abandoned coal mine fly – ash yard conversion into the solar PV park. The case study will involve technical, environmental and financial aspects to be solved individually by students in step-by-step approach under teacher supervision.

Learning outcomes

Students will be able to justify the need of energy technologies transition and decommissioning for using specific examples from various technological options, from legal, environmental and technological points of view. Also, they will get the ability to illustrate how fossil fuel based energy technologies can be converted into renewable energy systems together with most important and limiting factors; explain how existing coal regions can undergo the transition into non-fossil energy, energy – related or non-energy industries and give examples of successful case studies and propose one or more technological options for energy technology transition for selected post-coal region and support the choice with environmental analysis. Learning how to apply the concept of life cycle analysis to analyze a given fossil fuel based power plant decommissioning process and present the non-technological bottlenecks of energy transition and decommissioning processes will be additional benefits.

16. Energy storage for sustainable energy systems

The objective of the course is to provide students with an up to date knowledge on grid-scale energy storage technologies and their functionality in energy systems. The course also aims at development of skills and competences related to analysis and planning of energy storage projects. Students will be taught modeling and conceptual design of technological systems of energy conversion plants that realize energy storage in energy system. Objective of the course is also strengthening and practical application of knowledge acquired during the study of core subjects (thermodynamics, heat transfer, etc.).

How the course is conducted

Lecture: Thematic area of the lecture covers the following issues of the grid scale electric energy storage: 1) Energy system operation and introduction to energy storage; 2) Functionality and performance indicators of electric energy storage; 3) Characteristics of grid-scale energy storage technologies; 4) Design and operation of electric energy storage systems; 5) System integration of electric energy storage technologies; 6) Financial, economic, social and legal aspects of electric energy storage; 7) Specific case studies of energy storage plants focused on technology selection and optimization of structure for defined functionality and under local site specific conditions. There are studied and discussed conditions, parameters and limits for operation of different storage technologies. The course also incorporates active learning methods based on case studies of different projects. Students will be given cases of different type: diagnostic cases, find solution cases. They will work in small groups and exchange findings and results in open class discussion. Sample cases cover the following problems: business opportunities and facing energy storage challenges by start-ups, cooperation of energy storage with a wind farm, energy storage at energy consumer site, integration of energy storage with a power conventional plant.

Learning outcomes

Project: At the project students will design an energy storage plant in different technologies. They will make design assumptions, perform technical calculation, simulate plant performance within the annual period of operation and perform financial calculation to evaluate project's profitability. At least two different technologies will be compared. One is a conventional battery storage facility and the other one is more complex facility based on thermodynamic processes. Compressed Air Energy Storage with above ground storage vessels or Liquid Air Storage technologies will be taken into account. Students will build models of these plants using Excell spreadsheet integrated with Coolprop thermodynamic property library. By this approach they will have opportunity to develop modelling skills as well as deep understanding of technology operation principles. During the project's execution student will also train the following:

- Team building and teamwork at each step of the project,
- Division of work into tasks and stages,
- Progress monitoring using Gantt Chart and recording of each stage of the work,
- Presenting results,
- Writing reports.

17. Waste to Energy

The course is aimed at delivering the information about modern technologies and environmental restrictions of recovering energy from waste. The course covers the following general topics: solid waste composition and quantities, classification of fuels, energy potential in waste, waste management and segregation, waste to energy technology, emission and energy balance of waste incineration and Refuse Derived Fuel (RDF or SRF) technology.

How the course is conducted

Lectures are conducted in an interactive way with use of audiovisual tools. During the lecture problem questions/topics are raised, students take part in the discussion about existing solutions as criterions for choosing the best one. Students are encouraged to participate in discussions during lectures.

The second part of course is done combining project and laboratory classes. It is based on the research of waste substances to determine their fuel properties. Based on the knowledge acquired from lab research, on the tested waste, students propose and develop a method of managing these waste.

Students would require not only to use the knowledge in the field of waste to energy but also the skills of analysis the legal and economic aspects on this subject. And most importantly, they will gain the ability to work independently in a chemical laboratory, which can be useful in later professional career. Students will be devided into small groups cooperating with each other to achieve a common end result.

Learning outcomes

After the course students will be able to define the key points of various Waste to Energy technologies from technological and environmental points of view. They will also improve their soft skills such as team work, leadership and interpersonal skills.

18. Circular economy

Course is focused on introduction to concept of circular economy with special emphasizes especially in energy sector. Economic, societal and environmental perspective is presented on the basis of integral approach to a resource efficient future, necessitating cooperation of all stakeholders along the value chain. This links product and service design, supply chain management, manufacturing technologies, product and service use, product treatment at end-of-life, and business models and strategies such as portfolio management and branding.

How the course is conducted

The lecture is conducted in active learning style with such elements like discussion and brainstorming. On the basis of problem solving models students are engaged in process of adaptation of specific processes to principles of circular economy. The case teaching in Harvard style is used.

Learning outcomes

Students will gain knowledge on the current stage of implementation of circular economy principles and will skills in problem solving focused on circular economy implementation.

19. Energy policy and world energy sources/Energy economics

The course if focused on introduction to the theoretical and empirical perspectives on individual and industrial demand for energy together with energy supply, energy markets, and policies affecting energy markets. The global supply and resources of energy carriers is discussed together with the grid of interactions. The global perspective of energy mix including oil, natural gas, electricity, renewable sources and nuclear power presented.

How the course is conducted

The lecture is conducted in active learning style with such elements like discussion and brainstorming. The course is supported by online sources of information. The practical case is presented in Harvard style as well.

Learning outcomes

The course will raise the awareness of cross dependences in power sector together with feasibility of implementation of different solutions.

20. Air quality impact assessment

The aim of this subject /module is to educate student as the future experts in air protection who would be able to prepare the reports on air pollution impact assessment, describing the current situation and forecast / prognosis, as well as, the various scenarios of the improvement of air quality.

Way of conducting the course

Students are learned how to operate the air samplers by performing measurements (according to the philosophy: "learning by doing") which is needed to increase their manual skills. Moreover, they are gained experience in analysis and interpretation of the measurement data. Next, they assess the exposure and risk of adverse health effects among exposed people in the selected areas ("case study teaching"). They also prepare the optimal scenario of the improvement of air quality. This goal is achieved mostly during the seminar discussions. It is also assumed that students would write brief information about the polluted areas for decision-makers and the exposed people.

Learning outcomes

The course will gives students the skills not only to assess whether the measured levels of concentration are below or above the standards, but also to estimate the possible adverse health effects caused by the analyzed pollutants inhaled by the exposed people (population). Additionally, they will be able to analyze the necessary, but at the same time technically and economically feasible, ways to reduce exposure to improve human health.

21. Smart heating grids

The objective of the course is to provide students with an updated knowledge on transformation and evolution of district heating and cooling systems. Special emphasis is put on new concepts in district heating that are oriented on conversion of standard heating networks into more effective and flexible smart heating grids.

How the course is conducted

In the first part of the course fundamental principles of district heating and cooling engineering and issues of rational energy management will be explained. The second part of the course delivers innovative teaching contents and formats to address the issues of emerging field of smart district heating.

Learning outcomes

The course builds students' awareness, understanding, skills and competences required to plan, analyse, and develop innovative technological solutions in the field of district heating and cooling. It will also provide students with knowledge about new business opportunities in district heating sector.

22. Internship

The main purpose of 2months industrial internship is to give student practice in business environment together with shaping practical skills related to engineering practice. Positions in this activity are assigned responsibility for providing engineering expertise, guidance and technical assistance. Students should perform engineering tasks and by reviewing and evaluating the work of consultants, contractors and facility operators, under the supervision of a professional engineer.

The internship is intentionally linked with the master thesis and should be treated as an introduction to the master thesis performance. During the internship the support to students from the industrial partner is granted.

Students are taking internships in large power companies like: Shell, EDF, SUEZ, TAURON, Sumitomo or in small technological startups according to students preferences. The total number of industrial partners delivering internships to Energy Transition students is 50.

Way of conducting the course

The main purpose is to give student practice in business environment together with shaping practical skills related to engineering practice. Positions in this activity are assigned responsibility for providing engineering expertise, guidance and technical assistance. Students should perform engineering tasks and by reviewing and evaluating the work of consultants, contractors and facility operators, under the supervision of a professional engineer. his is the Engineer-in-Training level where incumbents will initially perform a variety of routine engineering tasks in a training status under close supervision. Incumbents will perform basic engineering tasks such as the review of less complex plans, performance of basic engineering calculations, the writing of permits, the performance of computer modeling, and the inspection of parts of an engineering project.

The learning outcomes

Student demonstrates skills necessary to perform tasks and solving problems in business environment and improved interpersonal competencies, creativity , leadership and teamwork skills.

Descriptions - AGH

1. Gasification

The module concerns solid fuel gasification technology and production plants integrated with gasification process. Students will design process related to gasification technology. The research module.

Way of conducting the course

Students will design the flow sheet of selected process related to coal gasification technology in ChemCad process simulator. Students then will calculate process parameters and prepare mass and energy balance. The results should by prepared in form of the short report.

During the project students will also prepare one presentation on the basis of selected scientific paper.

The learning outcomes

Students are able to describe advances in the field of the implementation of typical gasification processes, principles of their design and evaluation of technical and economic factor.

2. Environmental Protection in Energy Sector

Students learn basics of environmental protection and appropriate analytical methods. Relevant industrial case studies are discussed. Fild study is provided.

Way of conducting the course

During lectures industrially relevant cases are discussed. Problems are given to the students. The solutions are proposed by students and discussed during the lectures e.g. The company would like to install a modern DeSOx installation – they do not want, however, to build waste water treatment installation. Propose a solution. Discuss the advantages and disadvantages of your proposal. During laboratory classes students prepare report where the team should elect the leader of the group. Team leader identifies the task for each member of her/his team. The members are responsible for the tasks. The leader, apart from overseeing the task, undertakes also one task her/himself. One of the tasks for the leader is to organize a "brainstorming" – a discussion where All members of the group propose the solutions.

The learning outcomes

Student is able to assess the usefulness of the latest developments in environmental protection in fuel-energy sector. Student can perform critical analysis of existing technologies, especially in the field of environmental protection in coal-based energy sector.

3. Computer modelling of technological processes

Module introduce students to basic methods of building of GUI for process simulation models and construction of the calculation in the background.

Way of conducting the course

During lectures students get knowledge about drawing of the process diagram (flowcharting), Elemental operation description in classical sheeting program (MS Excel, Origin, etc.), The chosen methods of calculation programming (iteration, approximation etc.), Approximation, interpolation or extrapolation of the data, Filling of flowchart to flowsheet, Design of the complete process model. Optimization and simulation, Linear and nonlinear regression,Data feasibility, Data acqusition, Model stability and evaluation.

The learning outcomes

Student is able to explain how to implement computer methods for typical technological processes, principles of their design and evaluation of technical, economic factor as well as quality impact and he can describe analytically and numerically physical and chemical aspects in chemical technology.

4. Advanced coal technologies

Subject have research character during classes students modeling real power plant and analyzes influence CCS installation on main parameters power plant.

Way of conducting the course

Advanced coal technologies is organized in Learning by doing and project based learning manner. Based on actual data from industry, students in the program IPSEpro are modeling coal power plants and exploring ways to reduce its negative impacts in the environment and reduce CO2 emissions. Students assess during the discussion in terms of technical economic separation technology which CO2 would be the best to use in industrial scale. The selected technology is modeled in the program IPSEpro and then connected to the power plant. Students prepare a final report in groups in which they choose a leader who coordinates the work of other members of the group.

The learning outcomes

Student has knowledge of the functioning of the modern coal energy systems, their planning and development, taking account technical social, economic, environmental and legal issues. Can design a complex installation for coal fueled energy technology and CCS installation, using the advanced methods, techniques and tools, as well as their own idea, taking into account the set of specifications, environmental and social aspects

5. Business planning in energy sector

The aim is to develop business plans. Students propose projects, define needs and challenges addressed, make critical review of the literature and carry out the market research.

Way of conducting the course

Students will prepare and defend a business plan. At first students will be asked to prepare a number of different ideas for their business. They will present them and after brainstorming presentation of ideas they will select one that they will work on in groups. During preparation period, the students will be given consultations (on campus or, on demand by distance learning). The teaching material will be available at the Subject website. The course will be finalized by two meetings. During the meetings all students will present and defend the prepared business plans in front of the committee consisting of invited professors and possibly industrial representatives. Additionally, they will be asked to write a personal short paper on their experiences of the team work and giving own examples of their taking the responsibility.

The learning outcomes

Student can make a preliminary economic analysis of his/her proposal for a business in the fuel – energy sector. Student can determine the value that business brings to clients. He/she is able to analyse the market for the product/service and the competition. Student is able to write a business plan and to make an oral presentation in English for potential investors; can demonstrate his/her own contribution to the team work.

6. Unconventional Hydrocarbons

Students learn basics of unconventional energy resources and how assessment of the functioning of fuel-energy sector and forecast production of gas from shale gas reservoir and economics of gas production. Relevant industrial case studies are discussed.

Way of conducting the course

Unconventional Hydrocarbons is organized in learning by doing and project based learning manner. During classes students analyze industry case where they forecasting of production of gas from shale gas reservoir and analyze economics of gas production.

The learning outcomes

Student has the knowledge of methods of winning, preparation and application of fuel-energy raw materials, especially can explain basics of unconventional gas & oil extraction technology. Can carry out assessment of the functioning of fuel-energy sector and forecast production of gas from shale gas reservoir and economics of gas production

7. Chemical reactors

The subject is cognitively-practical, where students learn and then calculation kinetic and design the Batch Reactor, CSTR and series of reactors.

Way of conducting the course

Students during lecture solve real industrial problems where they select the most appropriate chemical reactor depending of mode of operation. Students on auditory classes calculation of current composition of reaction mixture, determinatin of kinetic equations from experimental data. They modelling of the batch chemical reactors, the isothermal continuous stirred tank reactors and isothermal cascades, the continuous plug-flow reactors.

The learning outcomes

The student is able to analyze models of ideal reactors and is able to explain the construction of chemical reactors used in the chemical industry, as well as select an appropriate reactor. Student can discuss of the role of design of chemical reactors particularly in chemical technology. Student can demonstrate her/his ability to take resposibility and collaborate with others when working in a team.

8. Chemistry of coal

This module gives deep inview on structure, physico-chemical properties and application of carbonaceous materials. Students experimentally evaluate some of properties of coal and active carbons.

Way of conducting the course

During lectures students will be acquainted with the most important issues in chemistry of coal . Lectures will concern the following subjects: Density of hard coal by pycnometry; Decolouring properties of hard and active coals; specific surface area of hard coal; Elemental analysis of hard coal; Surface groups of hard coal;Self-ignition of hard coal.

The learning outcomes

Student is able to define chemical composition and physicochemical and functional properties of carbonaceous materials. Student is able to carry out experiments in the physico-chemical laboratory, interpret the obtained results and formulate conclusions.

9. Students Research Group

During the course, students carry out research projects under the supervision of the project supervisor.

Way of conducting the course

Laboratory or project depending on Research Group chosen by the student.Depending on the chosen Research Group, the students will have to carry out short research projects either in laboratory, computer laboratory or by preparing a project. A group of students prepare a final report of experiments or calculations and a short presentation reporting the results. The group chooses a leader who is responsible for allocating and controlling tasks of other members of the groups. Each of the students in a group is responsible for the definite part of the report and the presentation. The presentation is accompanied by the discussion with other students. The students give an opinion on technological maturity of the researched problem and discuss the possibility of industrial implementation of project. The students have to give their opinion on ethical and ecological consequences of possible industrial implementation.

The learning outcomes

Student can categorise the method to solve the problem and choose the optimal one in connection with a project given by a Research Group Supervisor or chosen by the student after disscusion with the Supervisor. Student can prepare the plan and schedule of the project research.

10. Intellectual property rights

The course is of the practical character and has cognitive value in the intellectual property field.

Way of conducting the course

Lecture is interactive, the teacher asks a question during the lecture students are discussing it among themselves and with the teacher. During classes students do critical analysis of particular problem of the fuel-energy sector in the aspect of IP, including: conception of intellectual property; copyright laws and and industrial property; knowledge as intellecual property.

The learning outcomes

Student is able to define and explain the rules for the protection of industrial property and copyright law in the area of fuel - energy sector, understands the need for intellectual property management. Student can make a preliminary economic analysis of engineering actions, as well as can carry out a multidimensional assessment of the functioning of the fuel – energy sector and to forecast and plan its development at different levels of management

11. Planning and forecasting in energy sector

Lectures and other activities give the introductory knowledge on modeling fuels and energy systems, construction of equations, solving methods and ways of models' application.

Way of conducting the course

Classes is organized in Learning by doing and project based learning manner. Solving a real industry problem with the use of a model. Description of the problem:(The student has to formulate research idea basing on existing data) , identification of the system, model coding and solution, discussion of the results.

The learning outcomes

Student can apply the knowledge of processes of system identification, diversification of elements and relations, and forming appropriate models. Students can apply their understanding on the following objects used in modelling energy systems: sets, elements of sets, parameters, variables, equations, models.

12. Sustainable energy development

Module devoted to analysis of interrelations between energy use, environment and climate change.

Way of conducting the course

The aim of the project is to assess whether development of selected countries is becoming more sustainable with the use of Energy Indicators for Sustainable Development. Relevant indicators will address economic, social, and environmental aspects of development. The necessary calculus will be done based on data, mainly of World Bank, British Petroleum, EUROSTAT. Students will analyse the results and explain the reasons for observed changes in the values of indicators. Based on the results obtained and their observation of real life they will propose innovative solutions for changing the energy system into more sustainable one. The teaching material will be available at the Subject website.

The learning outcomes

Student is able to explain the functioning of the fuel – energy system, main drivers influencing its development; is able to define social, economic, environmental and legal aspects related to the fuel – energy system. Student can carry out a multidimensional assessment of the functioning of the fuel – energy sector of selected countries with the use of the energy indicators for sustainable development.

13. Heat and mass transfer processes in energy sector

The subject is cognitive-practical. Student knows basic concepts and definitions, calculation procedures. Solves problems in the field of chemical engineering processes

Way of conducting the course

Problems solving classes are carried out by small group of students or by individual student. They are instructed by assistant professor how the heat and mass transfer problems can be analysed. Then students are expected to undertake the number of small individual projects.

The learning outcomes

Student knows methods, techniques, tools used to solve simple engineering tasks in chemical technology. The student knows and understands in depth the processes taking place in the devices and technical systems

14. Biomass in Energy Applications

The subject is cognitive-practical. Student knows basic concepts of use biomass in energy applications

Way of conducting the course

Classes can include also a study visit to a company –a manufacturer of biomass boilers, with the presentation of technological process and discussion with different employeesfrom different departments of the company. During laboratory students Measurement of selected biofuels parameters (moisture/volatiles/ash content) in order to acquire data for project calculations they do studies of operation of selected components (exchangers, heaters, radiators) and simple ORC unit. Subject biomass in energy applications organized in Learning by doing and project based learning.

The learning outcomes

Student knows advanced methods of renewable energy sources use, storage and cooperation with fuel and energy systems and is able to search, evaluate and convert data from scientific literature and other selected sources

15. Energy policy

Module devoted to energy policy instruments to support the development of renewable energy sources.

Way of conducting the course

Students prepare project where development of a project on the energy policy of a given country. Geopolitical situation that determines the national energy policy is analysed. The student analyses the instruments of energy policy that are introduced in a given country and calculates energy security and energy intensity indices. Then author's evaluation of the national energy policy is carried out. Students present main findings and results of their study.

The learning outcomes

The student can: - justify the need for energy policy development; - list and describe the functioning of key energy policy instruments; - describe key objectives of the Polish Energy Policy until 2030, justify the selection of energy policy instruments to achieve these objectives; - list and describe the renewable energy development support schemes; - calculate selected indicators of energy security and energy intensity of GDP and interpret the results; - search for related scientific papers and use correct terminology in the field of energy policy.

16. Modern environmental analytics

Module devoted to specialized devices and software typical for modern environmental analytics.

Way of conducting the course

Subject modern environmental analytics organized in learning by doing and project based learning.During laboratory students 1. Environmental samples preparation (solid phase extraction and Soxhlet extraction).2.

Spectrometric methods in water and wastewater quality control.3. Measurement of total, organic and inorganic carbon in environmental samples.4. Separation, detection and determination of selected organic compounds (non-steroidal anti-inflammatory drugs, antibiotics and preservatives) in aquatic samples by means of high performance liquid chromatography (HPLC). 5. Analysis of oil samples using Fourier transform infrared spectrometer (FTIR).

The learning outcomes

Student is able to explain environmental analytics to perform various measurements using advanced techniques typical for instrumental analysis. Student can acquire and creatively process information from the scientific literature databases, and other properly chosen sources concerning about analytical methods in the field of environmental analytics

17. Mathematical modeling

Module is focus on presenting the mathematical technics behind the mathematical modeling used in process and economic analysis.

Way of conducting the course

Lectures and classes will concern the following subjects: Solving linear differential equations of higher order; Differential calculus of the multiple variable functions; Expanding functions into Fourier series, special cases of odd and even functions; The calculus of variations, Euler's equation.

The learning outcomes

Student is able to describe the typical structure of the model and can identify the main elements with their relations that occur in real fuel and energy systems. Student has knowledge of multi-variable differential calculus; knows how to find local and conditional extremas.

18. Catalysis in fuel industry and air pollution control

Research subject. Basing on acquired knowledge & literature research, choice, preparation & testing of adsorbents & catalysts

Way of conducting the course

The main objective of the course is to bring to the students the knowledge of the catalytic methods in fuel processing and environmental protection. The lectures are illustrated with industrially relevant case studies: e.g. what are the differences in the structure of HDS catalyst for light and heavy oil fractions, which catalysts are used in industry for DeNOx processes, etc. During lectures problems are presented to the students – the students discuss the possible solutions in the current or the following lecture. Students in the laboratory tend to create a new catalysts used for the reduction of harmful pollutants emitted from combustion gases into the atmosphere. Work on them is carried out in groups. During the course they receive the necessary information on the methods of creating Catalysts. In groups they prepare a methodology of creating Catalysts and after consultation with the professor and under his supervision are beginning to produce the catalyst according to the rules.

The learning outcomes

Student is able to explain and analyse surface phenomena, with special stress laid on catalytic processes, methods of preparation, structure and properties of catalysts. Student can assess the usefulness of the latest developments in catalysis, especially in respect to the fuel-energy sector. The student can perform critical analysis of existing technologies, especially in fuel-energy sector

19. Biotechnology

The aim of the subject is to acquire a fundamental knowledge on the biotechnology issues with special stress on the application of biotechnology in fuel processing and production or environmental protection. Students are introduced to the biochemistry and microbiology. They obtain the basic knowledge on bioreactors, fermenters and other equipment used in bioprocessing.

Way of conducting the course

Laboratory experiments in concentration in following topics: Fundamentals of biotechnology. After each laboratory experiment student prepare raportin groups max 2 person for each group and in conclusion of report students assessment results of experiment regarding to economic social technical way. Laboratories allow students to generate new ideas related to the improvement of many biotechnological processes and a completely different approach to many laboratory methods. When doing experiments, students use the knowledge gained during the course of study as well as the knowledge transferred from the lectures.

The learning outcomes

Student is able to prepare experiment related to biotechnology use in industry, especially in energy sector as an individual work or team labour. Student can define application of biotechnology for technological processes and renewable fuels production and processing.

20. Fluidization and Solid-Gas Systems

Following module has a strongly reasearch character. Students are obliged to solve practical problems connected to utilization of fluid beds in energy sector (gasification or combustion process).

Way of conducting the course

Each student will be provided with a set of pdfs containing lectures and technical data concerned with fluidization phenomenon. Students are then required to use the data for the process calculation and specific problems solution. The students will use MathCad engineering code for this practical activity.

The learning outcomes

Will be able to formulate and describe fluidization process arrangement and specific component's function, particularly in high velocity fluidization. Student can calculate main process parameters using numerical techniques and engineering software.

21. Carbon dioxide mitigation technologies

Research subject. Students have to find and critically evaluate literature on CO2 mitigation technologies & prepare a presentation based on it.

Way of conducting the course

The purpose of this course is to discuss an important opportunity which we should consider as part of technological response, namely the capture and sequestration of CO2 from large stationary sources. Seminar proceeds in the form of lawsuit: The whole group takes part in proceeding in the following roles: judge; prosecutor team (2-3 student), defence counsel (2-3 students) and jury (the rest of student group). After the first minute of each speech, members of the defence team may request a'point of information' (POI). If the judge accepts they are permitted to ask a question. POI's are used to pull the speaker up on a weak point, or to argue against something the speaker has said.

The learning outcomes

Can discuss the social role of the graduate of technical university, particularly in the dissemination of technical culture in society and can communicate in a meaningful and attractive way information on the achievements of applied chemistry and its effects on development of modern technologies, especially in the fuel – energy sector.

22. Advanced liquid biofuels

The course has a research character and concerns the information on the modern technologies of biofuels production and the basic analysis of physicochemical properties of the liquid fuels.

Way of conducting the course

The goal of the course is to present the outline of the contemporary used unconventional feedstock and the modern technologies of its processing towards sustainable biofuels as well as other valuable bioproducts useable for the energy and fuel sector. The overall objective of the course is to present to the students the main issues of conventional and modern, renewable fuels in view of both, environmental and economic aspects. The field of the course involves an interdisciplinary approach in which the students combine the knowledge in the topics of organic chemistry, physical chemistry, chemical engineering, analytical chemistry, the elements of biochemistry, molecular spectroscopy, and the environmental sciences. The laboratory part of this course has research character and is aimed to get the students closer to the basis of the modern fuel laboratory techniques and procedures. It envelops the information on the modern technologies of biofuels production and the basic analysis of physicochemical properties of the liquid fuels. The students have the opportunity to develop their laboratory manual skills (i.e. working with basic glass, transfer the chemicals, weighing, volume measuring and the work with advanced apparatus designed for physicochemical measurements). This, in turn, creates the possibility to transform the practical experiences into the solution of the practical problems (i.e. research challenges).

The learning outcomes

Student is aware of the importance and understanding of the effects of non-technical aspects and results of engineering activities of biofuels production and practical employment, especially in respect to environment and socioeconomic aspects. Student is able to plan and carry out experiments in chemical laboratory, and interpret the obtained results and formulate conclusions. Student is able to work individually and in a team, carrying out various functions.

23. Renewable Energy

The teaching methods consist of traditional lectures, recitations and active teaching methods laboratory. The course covers the following general topics: renewable Energy and use renewable source in energy sector.

Way of conducting the course

The course is conducted in active learning manner. Students measure performance of solar flat-plate and evacuated collectors, efficiency of photovoltaic module with/without the Sun tracer, test efficiency of model energy systems (wind turbine, water Pelton turbine), conduct measurements of full scale biomass system (boiler with storage unit), hydrogen systems with fuel cells.

The learning outcomes

Student can define the social role of the graduate of technical university, particularly in the dissemination of technical culture in society and communicating in a meaningful and attractive way information on the achievements of applied energetics and its effects on development of modern technologies, especially in the renewable energy sector.

24. Fuel Cells and Hydrogen Production

During the course the students get fundamental knowledge on hydrogen technologies as well as fuel cells and on possibility application them in power-sector, transport and avionics

Way of conducting the course

During the course students will be participating in laboratory exercises, discussions, work individually and in teams. They will be learning based on didactic materials, instructions working with different electrochemical devices and apparatus, gain practical skills and knowledge, solving real problems in hydrogen and fuel cells area. Case teaching methodology will be also used during the lectures of the course as well as laboratory part of subjects. Working on the case presenting different types of challenges in TES field will support appreciation of ethical, scientific and sustainability challenges as they pertain to their field of work . Lectures are based on active teaching methods.

The learning outcomes

Student can assemble fuel cell from elements, operates the fuel cell and stack of fuel cells, as well as measure its basic parameters (e.g. the maximum power, electrical efficiency). Student exolains principles of operation of main electrochemical devices: electrolyzers, sensors and galvanic cells and their applications in practice.

25. Low emission combustion

During the course the students get fundamental knowledge on Ecological noxiousness of combustion, mechanisms leading to formation and emission of nitrogen oxides, sulphur oxides, carbon monoxide, hydrocarbons and particulate matter in the course of combustion.

Way of conducting the course

Problems solving classes are carried out by students. They are instructed by assistant professor how to design devises of noxious substances reduction. Then students are expected to undertake a number of small individual projects. The laboratory exercises are based on a series of experiments carried out by students. The experiments are carried out in small groups. Students need to acquire knowledge about the processes, experimental facilities and procedures prior to the lab, based on materials prepared by the instructors. Then students are expected to prepare reports from each experiment.

The learning outcomes

Student is able to select and design primary and secondary technologies for emission reduction of noxious compounds typical for energy sector. Student can identify conditions (type of boiler, fuel, operating conditions) which cause a risk of pollutants formation.

26. Ceramic materials for energy industry

The main objective of the course is to bring to the students the knowledge of the physicochemical properties of ceramic materials and their possible application to energy industry

Way of conducting the course

The course is built of lectures and laboratory.During lectures students will be acquainted with the most important issues in materials science and technology. Lectures will concern the following subjects: Introduction of ceramic materials, ceramic for turbine engines, thermal barrier coatings, corrosion of selected ceramic materials in hot gas environment, ceramic membranes in carbon dioxide capture applications and potentials, Direct carbon fuel cell, solid oxide fuel cells , ceramic materials for renewable energy

The learning outcomes

Compare a preliminary economic analysis of engineering activities undertaken, as well as may conduct a multi-faceted assessment of the functioning of systems - fuel energy and to develop a forecast and plan their development at different levels management. Student is aware of the importance and understanding of non-technical aspects and impacts of engineering, including its impact on the environment and the associated liability decisions, has eco-friendly attitude

27. CFD modeling with ANSYS Fluent

This course gives detailed information how to create geometry, generate the mesh as well as how to set up, run and post-process the results.

Way of conducting the course

The course is conducted in active learning manner. The teaching methods consist of traditional lectures, recitations and active teaching methods learning by doing. During lectures students will be acquainted with the most important issues fundamental governing equations – continuity, momentum and energy and methodology of solving CFD problems.

The learning outcomes

Student is able to use commercial software for simulation of heat and mass transfer processes typical for energy sector. Student is able to investigate of heat and mass transfer processes typical for energy sector and design appropriate equipment.

28. Radioactive elements in power industry and soil pollution control

Student get the theoretical and practical information of radiation analysis in different samples.

Way of conducting the course

The teaching methods consist of traditional lectures, laboratory classes, seminar classes. During classes students will be acquainted with analytical process in alpha and gamma spectrometry (sample preparation, spectrum analysis, alpha and gamma spectrometry measurements).

The learning outcomes

Student can prepare the samples for radioanalytical analysis, make radioanalytical measurement (gamma and alpha spectrometry). Student can: explain the kind of ionization radiation, distinguish natural and artificial radionuclide characterize environmental pollution explain the basis of radiochemistry techniques.

29. Eco-Innovation in Industry

This course gives detailed information about method of innovation and eco-innovation assessment and solution.

Way of conducting the course

The seminars will give students experience in the following applications of project management: identification of eco-innovative solutions, method of innovation and eco-innovation assessment hours, best practises – Case studies of eco- innovative solutions applied by industry, possibilities of financial support for eco-innovative solutions – eco-innovation project management .

The learning outcomes

The student can assess eco-innovation solutions using indicators and different programmes. The students is able to create and present the final conclusion based on prepared report.

30. Smart heating grids

During the course the students get fundamental knowledge on thermal energy storage methods and on application of heat and cold storage in energy systems and residential applications.

Way of conducting the course

During the course students will be participating in discussions, work individually and in teams. They will be learning based on didactic materials, working with different type of text, searching for information independently. Case teaching methodology will be also used during the selected classes of the course. Working on the case presenting different types of challenges in TES field will support appreciation of ethical, scientific and sustainability challenges as they pertain to their field of work. Lectures are based on active teaching methods. Working on the case, working in the teams, discussion on possible solutions will be part of acquiring competences in the area of creativity skills and competences

The learning outcomes

Student is aware of his/her responsibility for implementation of tasks realized in a team. Student is familiar with advanced methods of using renewable energy resources, including their storage and collaboration with fuel - energy systems

31. Internship

The main purpose of 2months industrial internship is to give student practice in business environment together with shaping practical skills related to engineering practice. Positions in this activity are assigned responsibility for providing engineering expertise, guidance and technical assistance. Students should perform engineering tasks and by reviewing and evaluating the work of consultants, contractors and facility operators, under the supervision of a professional engineer.

The internship is intentionally linked with the master thesis and should be treated as an introduction to the master thesis performance. During the internship the support to students from the industrial partner is granted. Students are taking internships in large power companies like: Shell, EDF, SUEZ, TAURON, Sumitomo or in small technological startups according to students preferences. The total number of industrial partners delivering internships to Energy Transition students is 50.

Way of conducting the course

The main purpose is to give student practice in business environment together with shaping practical skills related to engineering practice. Positions in this activity are assigned responsibility for providing engineering expertise, guidance and technical assistance. Students should perform engineering tasks and by reviewing and evaluating the work of consultants, contractors and facility operators, under the supervision of a professional engineer. his is the Engineer-in-Training level where incumbents will initially perform a variety of routine engineering tasks in a training status under close supervision. Incumbents will perform basic engineering tasks such as the review of less complex plans, performance of basic engineering calculations, the writing of permits, the performance of computer modeling, and the inspection of parts of an engineering project.

The learning outcomes

Student demonstrates skills necessary to perform tasks and solving problems in business environment and improved interpersonal competencies, creativity , leadership and teamwork skills.