

COURSE DESCRIPTION CARD – MODULE 4

Field of study	International Interdisciplinary Summer School "Energy-efficient construction, users and environment friendly"					Programme type	Summer course
Module name	The use of ecological sources of heat and electricity					Course code	IISS2026-M4
						Course type	obligatory
Forms and number of hours of tuition	L	LC	P	SW	FW	Language	English
	1	5		4			
Course objectives	<p>An overview of the latest heat and electricity sources available on the global market using non-fossil energy sources, including solar, wind, hydrothermal, and biomass energy. Students will be introduced to the many available solutions and their importance in both energy conservation and environmental protection.</p> <p>Presentation of the basic operating parameters and characteristics of heat pumps, wind turbines, biomass, hydrothermal energy, photovoltaic panels, and solar collectors. The ability to select and optimize systems using ecological energy sources.</p> <p>The ability to select selected heat generation solutions for heating and domestic hot water systems based on air and ground heat pumps, biomass, and solar collectors, as well as electricity generation based on solar, wind, and hydrothermal energy. Presentation of the operating principles, types, and criteria for selecting selected solutions based on the building's energy needs, climatic conditions, and technical parameters of the installation. A discussion of the use of solar collectors in solar power plants, their role in concentrated solar power (CSP) systems, and the possibilities of integration with other energy sources. Regardless of the technological solutions, the impact of local climate on the use of renewable energy sources is highlighted.</p>						
Course content	<p>The program content includes:</p> <ul style="list-style-type: none"> – analysis and selection of heat generation solutions in heating systems and domestic hot water systems using air and ground heat pumps and solar collectors, – characteristics of wind turbines, including the principles of converting wind kinetic energy into mechanical and electrical energy, turbine types (HAWT, VAWT), power curves, aerodynamic parameters of blades, the impact of turbulence and terrain on energy production, and criteria for selecting wind farm locations, – analysis of biomass-based systems, considering the types of biomasses (solid, liquid, gaseous), their energy properties, combustion and co-firing technologies, pyrolysis and gasification processes, as well as the design of biomass boiler plants, considering the fuel and emission balance, – discussion of hydrothermal energy technologies, including the principles of heat recovery from surface and groundwater, characteristics of heat pump systems using hydrothermal energy (water-to-water), efficiency parameters, and environmental and operational factors affecting their operation. installation, – discussion of design criteria determining the selection of an appropriate heat source, such as seasonal heat demand of the facility, parameters of the receiving installation, 						

	<p>climatic conditions, energy efficiency of equipment, power balance, and an economic and environmental analysis of the proposed solutions,</p> <ul style="list-style-type: none"> – discussion of the construction, principles of operation, and operating parameters of photovoltaic systems, – discussion of the principles of converting solar radiation into electricity, the impact of atmospheric conditions on energy yields, module operating parameters (open-circuit voltage, short-circuit current, maximum power point – MPP), cooperation with inverters, and principles of PV system design, considering system losses, – the operational characteristics of heat pumps, PV modules, and solar collectors; a discussion of COP/SCOP coefficients of performance for heat pumps, temperature and pressure characteristics of solar collectors, optical efficiency and thermal losses, as well as power and temperature curves for PV modules. – review of solar collector applications in solar power plants, including concentrated solar power (CSP) systems, the design of parabolic trough systems, Fresnel mirrors, and solar tower installations, along with the characteristics of the working medium, the heat storage process (e.g., in molten salts), and integration with conventional turbine systems. <p>Completion of a design task related to the selection of the power of selected devices for given data related to the existing energy performance of the facility. Workshop exercises in four-person interdisciplinary and international student groups under the supervision of two faculty members. The workshop objectives will be achieved through:</p> <ul style="list-style-type: none"> – presentation and discussion of selected energy sources, – familiarizing participants with the construction and operating principles of devices and the factors influencing their efficiency, – discussion and exchange of views with students on the impact of climatic conditions on the selection of appropriate solutions, – project teams conducting technical, economic, and ecological analyses of selected technologies, – discussion of the benefits and limitations of the proposed solutions with the instructor, – selection of the optimal solution by the project teams, – presentation of results and discussion of the concepts proposed by the teams, – the selection of energy sources considering local climatic conditions will also provide a basis for discussion on the impact of climate on the designed power and efficiency of the analysed systems, – the international and interdisciplinary composition of the project groups will enable participants to examine heat source selection from the perspective of their own experiences with their local climate. <p>An additional outcome of the workshop will be the integration of students and the development of their language skills, communication skills, and the ability to collaborate in an international team.</p>
<p>Teaching methods</p>	<p>Lecture, workshop, carrying out a design work, performing laboratory exercises</p>
<p>Assessment method</p>	<p>Defence of project tasks, evaluation of final report and test</p>

Symbol of learning outcome	Learning outcomes	Reference to the learning outcomes for the field of study
L01	construction, principles of operation and exploitation of modern devices used in refrigeration, heating, ventilation, air conditioning	K_IISS_W02
L02	basic principles of energy conversion in photovoltaic, wind, hydro, and biomass systems	K_IISS_W03
L03	methods for resource analysis and site selection for renewable energy installations	K_IISS_W05
L04	conduct an analysis of local resources (wind, sun, biomass, water) and perform a technical and economic analysis of renewable energy investments	K_IISS_U02
L05	use scientific, popular science and industry literature, subject standards, legal acts, internet databases in English language; properly use the information obtained, as well as formulate and present opinions	K_IISS_U05
L06	properly select the technical conditions for building design in relation to climatic conditions to design selected elements of renewable energy systems	K_IISS_U06
L07	use calculation methods for assessing the energy, economic and ecological efficiency of investments based on renewable energy sources	K_IISS_U08
L08	critical evaluation of research results and popularization of renewable energy solutions	K_IISS_K01
Symbol of learning outcome	Methods of assessing the learning outcomes	Type of tuition during which the outcome is assessed
L01	Defence of the project tasks, test and final report.	SW, L, LC
L02	Defence of the project tasks, test and final report.	SW, L
L03	Defence of the project tasks, test and final report.	SW, LC
L04	Execution and verification of the report.	LC, SW
L05	Defence of the completed project.	SW
L06	Defence of the completed project.	SW
L07	Defence of the completed project, test and final reports.	LC
L08	Defence of the completed project, test and final reports.	LC
Student workload (in hours)		No. of hours
Calculation	Participation in the lecture.	1
	Participation in workshop.	4
	Participation in laboratory classes.	5
	Preparation of project tasks.	4
	Preparation of reports.	4
	Preparation for the final test.	4
	Consultation.	2
	TOTAL:	24

Quantitative indicators		HOURS	No. of ECTS credits
Student workload – activities that require direct teacher participation		11	0,44
Student workload – practical activities		21	0,84
Basic references	<p>Krawczyk D. (red.), Buildings 2020+. Energy sources. Białystok, Oficyna Wydawnicza Politechniki Białostockiej, 274 s., ISBN 978-83-65596-72-7, 2019 DOI:10.24427/978-83-65596-73-4.</p> <p>Andrew D Chiasson, Geothermal heat pump and heat engine systems: theory and practice; Hoboken: ASME Press; Chichester: Wiley, 2016.</p> <p>Vasile Minea, Heating and cooling with ground-source heat pumps in cold and moderate climates. Vol. 1, Fundamentals and basic concepts, Boca Raton; London; New York: CRC Press Taylor & Francis Group, 2022.</p> <p>Jingxin Wan, Forest and biomass harvest and logistics, Cham: Springer, 2022.</p> <p>Xiao, Weidong. Photovoltaic Power System. 1st ed. New York: Wiley, 2017. Web.</p> <p>Sonnenenergie, Deutsche Gesellschaft Fur. Planning and Installing Photovoltaic Systems. London: Taylor and Francis, 2013. Planning and Installing.</p> <p>Grassi W., Heat Pumps: Fundamentals and Applications, Springer International Publishing AG, 2017.</p> <p>Martín Chivelet, Nuria et al., Building-Integrated Photovoltaics: A Technical Guidebook, Milton: Routledge, 2025.</p> <p>Hau, Erich, Wind Turbines: Fundamentals, Technologies, Application, Economics, Berlin, Heidelberg: Springer Berlin Heidelberg, 2013.</p> <p>Sathyajith M., Wind Energy Fundamentals, Resource Analysis and Economics, Springer-Verlag Berlin Heidelberg 2006</p> <p>Francis de Winter, Solar Collectors, Energy Storage, and Materials, The MIT Press</p>		
Organisational unit conducting the course	Department of HVAC Engineering, BUT with participation of abroad expert	Date of issuing the programme	
Author of the programme	dr inż. Piotr Rynkowski	05.12.2025	

L – lecture, LC – laboratory classes, P – project, SW – specialization workshop, FW - field work