STUDY MODULE DESCRIPTION FORM

Name of the module/subject **Heating Systems**			Code **1010102221010132038**
Field of study **Environmental Engineering Second-cycle**		Profile of study (general academic, practical) **general academic**	Year /Semester **1 / 2**
Elective path/specialty **Heating, Air Conditioning and Air Protection**		Subject offered in: **Polish**	Course (compulsory, elective) **obligatory**
Cycle of study: **Second-cycle studies**	Form of study (full-time,part-time) **full-time**		
No. of hours Lecture: **30** Classes: **-** Laboratory: **15** Project/seminars: **30**			No. of credits **5**
Status of the course in the study program (Basic, major, other) **other**	(university-wide, from another field) **university-wide**		
Education areas and fields of science and art **technical sciences** **Technical sciences**			ECTS distribution (number and %) **5 100%** **5 100%**

Responsible for subject / lecturer:

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Prerequisites in terms of knowledge, skills and social competencies:

1	**Knowledge**	Basics of thermal engineering and fluid mechanics, heating - level 6 of NQF. The student has a structured, theoretically founded basic knowledge of issues related to the design of central heating systems.
2	**Skills**	Basics of thermal engineering and fluid mechanics: solving problems and making measurements at level 6 of NQF. The student is able to formulate and solve mass and energy balances for simple systems, under steady-state conditions as well as convert the units of physical quantities for heat transfer and fluid mechanics? problems. The student can operate basic computer programs: CAD, Excel, Word
3	**Social competencies**	Awareness of the need to constantly update and supplement knowledge and skills.

Assumptions and objectives of the course:

Extending and deepening the knowledge and skills in the scope of design, operation and simulation analysis of complex heating systems, including the use of renewable energy sources.

Study outcomes and reference to the educational results for a field of study

Knowledge:

1. The student has structured and theoretically founded knowledge of the methods for assessing the energy consumption in a building. - [-]

2. The student has structured knowledge of developments in the area connected with heating systems and possible applications of low-temperature heat sources. - [-]

3. The student knows the structure and elements of heating and hot water systems cooperating with renewable energy sources related to the building energy needs standard. - [-]

4. The student has expanded and theoretically founded knowledge of the possibilities of using solar thermal collectors in heating and hot water systems. - [-]

5. The student knows the methods of calculation and simulation, tools and materials used in solving the engineering tasks related to design of heating and hot water systems cooperating with renewable energy sources. - [-]

6. The student knows the methods of assessment for buildings and energy installations during life cycle as well as methods of assessment of energy and economic efficiency for thermomodernization. - [-]

7. The student knows the areas of application and performance parameters for thermographic cameras and the effect of surface emissivity on thermographic measurement results. - [-]

8. The student knows the impact of the lack of airtightness on the effective heat recovery efficiency of an air heating system. - [-]

Skills:

1. The student can formulate a concept and design solutions for heating and hot water systems using renewable energy sources, including selection of components with the help of professional computer packages. - [-]

2. The student is able to perform an energy ? ecological evaluation of a self-designed complex installation system. - [-]

3. The student can use a Minneapolis Blower Door device as well as specialized software in order to measure the air tightness of a room. - [-]

4. The student knows how to operate the thermographic camera, use specialized software for thermal imaging, interpret and evaluate the thermal images, assess the condition of pipe insulation and building insulation on the basis of thermal images. - [-]

5. The student is able to plan and carry out an experiment: measuring the energy efficiency of an air-to-air heat pump - [-]

Social competencies:

1. The student understands the need for teamwork in solving theoretical and practical problems. - [-]

2. The student is aware of the need to reiterate the steps of measuring and evaluating the uncertainty of the results of measurements and calculations. - [-]

3. The student sees the need for systematic deepening and extending their competences. - [-]

Assessment methods of study outcomes

Lecture

? The written examination, in doubtful cases followed by an oral examination.

? Final evaluation of the exam takes into account the result of the test and grades earned for the design and laboratory exercises.

Class Project

? Design of a complex heating and hot water system using renewable energy sources, prepared with the use of professional computing packages and individual spreadsheets software.

? Oral defense of the project

? Additional mark as a reward for regular participation and timeliness.

Laboratory exercises:

? the so-called input tests

? development and individual defense of reports.

Course description

Use of solar energy for domestic hot water and heating systems of buildings. Active systems for direct and indirect use of solar energy. Construction of a flat plate and vacuum solar collectors. Temporary and long-term efficiencies of the solar collector. The equation for the efficiency of a solar collector. Technological characteristics of solar collector components. Air solar collectors - characteristics and examples of solutions. Diagrams of solar thermal systems. Criteria for small and large solar installations. Design principles for small solar installations. Types of solar storage tanks. Examples of solutions and components of solar installations for domestic hot water preparation. Large solar installations for the purpose of heating and hot water systems, with buffers and the charging and discharging exchangers. Principles of design and operation of large solar installations. Design of solar collectors? fields. Situating and connecting collectors. Determination of flow rate, the dimensioning and selection of solar circuit pumps. Stagnation in solar systems. System pressure and emergency coolers. Determination of steam range. Selection of a cooling vessel. Character of selection of the expansion vessel for solar installations. F-chart method for the analysis of the effectiveness of a solar thermal system for heating and domestic hot water purposes. Types of passive solar systems. Energy balance of a window and envelope with transparent insulation. Energy efficiency of system of direct and indirect gains. Heating and ventilation systems cooperating with renewable energy sources. Cooperation between heating, ventilation and air-conditioning systems, fan coil units. Photovoltaic cells - connector structure, technical specifications, module structure, connection to the power grid, simplified selection of the PV generator. Thermal energy storage for heating systems. Selection of materials for energy storage. Examples of long - term battery solutions and rules of their choice. Examples of cooperation solutions for long - term energy storage with the heating system. Evaluation of the economic effectiveness of thermomodernization investments. Determination of annual operational costs of heating and hot water systems. Replacement and upgrade of installations in buildings, their energy and economic efficiencies. Analysis of the energy needs, delivered energy and primary energy for selected complex heating systems. Ecological and energy evaluation of building heat supply systems. Economic evaluation of the system based on the global cost method. Modelling of thermal states of buildings and installations. Example cases of application of elementary balance method. Steam high and low pressure installations.

Laboratory exercise topics:

1. Measurement of air tightness of a room.

2. Infrared camera inspection of a building, interpretation and evaluation of thermograms.

3. Measuring authority of a radiator valve, adjustment of valves in a water heating system.

4. Planning and execution of an experiment: measuring the energy efficiency of an air-to-air heat pump.

Basic bibliography:

1. Chwieduk D.: Energetyka słoneczna budynku Arkady Warszawa 2011
2. Foit H.: Zastosowanie odnawialnych źródeł ciepła w ogrzewnictwie i wentylacji Wydawnictwo Politechniki Śląskiej Gliwice 2010
3. Koczyk H., Antoniewicz B., Basińska M., Górka A., Makowska-Hess R.: Ogrzewnictwo Praktyczne projektowanie, montaż, certyfikacja energetyczna, eksploatacja Systherm Serwis, Poznań 2009
4. Laskowski L.: Ochrona cieplna i charakterystyka energetyczna budynku. Oficyna Wydawnicza Politechniki Warszawskiej. Warszawa 2005r
5. Mizielińska K., Olszak J.: Parowe źródła ciepła. WNT 2009.
6. Recknagel, Schramek, Sprenger, Honmann: Kompendium wiedzy OGRZEWNICTWO, KLIMATYZACJA, CIEPŁA WODA, CHŁODNICTWO 08/09 OMNI SCALA, Wrocław, 2008
7. Rubik M. : Pompy ciepła Poradnik Ośrodek Informacji Technika Instalacyjna w Budownictwie, Warszawa, 2006

Additional bibliography:

1. Duffie J.A., Beckman W.A.: Solar Engineering of Thermal Processes John Wiley Sons, Inc., New York 1991
2. Hensen J.L.M., Lamberts R. (red) Building Performance Simulation for Design and Operation, Son Press 2011
3. Nowak H.: Zastosowanie badań termowizyjnych w budownictwie Oficyna Wydawnicza Politechniki Wrocławskiej Wrocław 2012
4. Smolec W.: Fototermiczna konwersja energii słonecznej, PWN, Warszawa 2000

Result of average student's workload

Activity	Time (working hours)
1. Participation in lectures	30
2. Participation in laboratory exercises	16
3. Participation in projects	30
4. Preparation to laboratory exercises	15
5. Preparation to attend and pass the exam	30
6. Participation in the consultation	5
7. Project realisation	30

Student’s workload

Source of workload	hours	ECTS
Total workload	150	5
Contact hours	84	2
Practical activities	45	3