# STUDY MODULE DESCRIPTION FORM

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|---|---|---|
| Name of the module/subject<br>**Audyting and Energy Management** | | Code<br>**1010102221010130351** |
| Field of study<br>**Environmental Engineering Second-cycle** | Profile of study (general academic, practical)<br>**(brak)** | Year /Semester<br>**1 / 2** |
| Elective path/specialty<br>**Heating, Air Conditioning and Air Protection** | Subject offered in:<br>**Polish** | Course (compulsory, elective)<br>**obligatory** |
| Cycle of study:<br>**Second-cycle studies** | Form of study (full-time,part-time)<br>**full-time** | |
| No. of hours<br>Lecture: **30** Classes: **15** Laboratory: **-** Project/seminars: **-** | | No. of credits<br>**3** |
| Status of the course in the study program (Basic, major, other)<br>**(brak)** | (university-wide, from another field)<br>**(brak)** | |
| Education areas and fields of science and art | | ECTS distribution (number and %) |

## Responsible for subject / lecturer:

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## Prerequisites in terms of knowledge, skills and social competencies:

| | | |
|---|---|---|
| 1 | **Knowledge** | Classification of renewable and non-renewable primary energy sources, evaluation of energy capacity of demand and supply side of energy market; ,<br>Principles of energy balancing, economic and ecological evaluation of energy systems in built environment. |
| 2 | **Skills** | Application of energy balance equation in evaluation of energy systems in built environment;<br>Calculation of coefficients of energy, economic and ecolgic efficiency of energy systems in built environment; |
| 3 | **Social competencies** | Awareness of the need to constantly update and supplement knowledge and skills. |

## Assumptions and objectives of the course:

Widening by the students the knowledge and skills in energy management necessary to solve complex tasks of energy flows occurring in the built and natural environment.

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

### Knowledge:

1. The student has a theoretical and practical knowledge on the energy balancing of complex energy systems in built environment - [K2_W03, K2_W04, K2_W07]
2. The student has a theoretical and practical knowledge on the exergy balancing of complex energy systems in built environment - [K2_W03, K2_W04, K2_W07]
3. The student knows and understands the causes of irreversibility of real energy systems in built environment - [K2_W03, K2_W04, K2_W07]
4. The student knows principles of reducing the causes of irreversibility of real energy systems in built environment - [K2_W03, K2_W04, K2_W07]
5. The student knows dynamic methods of economic evaluation in energy management - [K1_W06]
6. The student knows the principles of energy auditing of buildings and technical equipment of buildings - [K2_W03, K2_W04, K2_W06]
7. The student knows the principles of multicriteria evaluation of energy systems in built environment - [K2_W03, K2_W04, K2_W06]

### Skills:

1. The student can construct evaluation model and energy and exergy balance equations for simple and complex energy systems in built environment - [K2_U09, K2_U10]
2. The student can calculate energy efficiency of simple and complex energy systems used in built environment - [K2_U12, K2_U18]
3. The student can calculate exergy efficiency and identify causes of irreversibility of simple and complex energy systems used in built environment - [K2_U01, K2_U08, K2_U18]
4. The student can calculate net present value (NPV) and internal rate of return (IRR) for elements and energy systems used in built environment - [K2_U14]
5. The student is able to choose on the basis of multicriteria analysis the recommended scenario of energy management in built environment - [K2_U10, K2_U14]

**Social competencies:**

1. The student understands the need for teamwork in solving theoretical and practical problems - [K2_K03]
2. The student is aware of the need to sustainable development in energy management - [K2_K05]
3. The student sees the need for systematic increasing his skills and competences - [K2_K01]

## Assessment methods of study outcomes

Lectures

Written test of competences (10 questions based on case study calculations)

Continuous assessment during lectures (rewarding activity of the students).

Tutorials

Final written colloquium ? 3 examples on energy, exergy and economic analysis

Continuous assessment of the students (rewarding students activity).

## Course description

Lectures:

Basic knowledge on auditing and energy management: definition of energy management, non-renewable primary energy sources, renewable primary energy sources, upgraded fuels, energy chain, gross and net energy efficiency, coefficient of non-renewable primary energy consumption, coefficient of carbon dioxide emission.

Principles of energy balancing of simple and complex energy systems in built environment, calculation of energy efficiency of complex energy systems in built environment;

Irreversibility of real thermodynamic processes. Gouya-Stodoli Law; the causes of irreversibility of real thermodynamic processes; exergy balance of thermodynamically open system; physical and chemical exergy of substance; exergy efficiency of thermodynamically open system; the measures of limitation of irreversibility of real thermodynamic processes;

Static and dynamic methods of economical evaluation of energy systems in built environment: simple payback time (SPBT), net present value (NPV), internal rate of return (IRR), total operation cost (TOC);

Principles of energy auditing: evaluation of energy use in buildings and technical systems of buildings; identification of technically acceptable scenarios of building?s retrofitting process, evaluation of chosen scenarios using energy, economy and ecological criteria;

Multicriteria methods in evaluation of energy projects in built environment: weighted sum method, outranking method (ELECTRE III/IV);

Tutorials:

1. Energy balancing of complex energy systems in built environment
2. Exergy balancing of complex energy systems in built environment
3. Calculation of economic efficiency of Energy systems in built environment
4. Multicriteria evaluation of energy systems in built environment

## Basic bibliography:

1. Szargut J., Ziębik A.: Termodynamika techniczna. Warszawa, WNT 2001.
2. Marecki J.: Podstawy przemian energetycznych. Warszawa, WNT 2000.
3. Chmielniak T: Technologie energetyczne. Warszawa, WNT 2008.
4. Szargut J., Guzik J.: Programowany zbiór zadań z termodynamiki technicznej. Warszawa, WNT 1980.
5. Rocznik statystyczny Rzeczpospolitej Polskiej 2010. Warszawa, ZWS 2011.
6. Mróz, T.M.: Planowanie modernizacji i rozwoju komunalnych systemów zaopatrzenia w ciepło. Wydawnictwo Politechniki Poznańskiej, seria rozprawy Nr 400, 2006.
7. Mróz, T.M.: Energy Management in Built Environment. Tools and Evaluation Procedures. Wydawnictwo Politechniki Poznańskiej, 2013.

**Additional bibliography:**

1. Kreith, F., West, R.E.: CRC Handbook of Energy Efficiency. CRC Press Inc. 1997.

**Result of average student's workload**

| Activity | Time (working hours) |
|---|---|
| 1. Participation in lectures | 30 |
| 2. Participation in tutorials | 15 |
| 3. Participation in consultations related to the tutorials | 3 |
| 4. Preparation for the final colloquium | 23 |
| 5. Preparation for the final test of lectures | 10 |

**Student's workload**

| Source of workload | hours | ECTS |
|---|---|---|
| Total workload | 81 | 3 |
| Contact hours | 48 | 2 |
| Practical activities | 15 | 1 |