Table S2.6.4. Form for the preparation of the course information sheets

Name of the subject: ***Energy efficiency of buildings***

Code of the subject	Status of the subject	Semester	Number of ECTS credits	Class load
	Optional	I	10	2+0+2

Study programme for which it is organised:
Doctoral studies in sustainable development, MARDS

Dependency by other subjects: None

Objectives of studying this subject: The goal of this course is that PhD students: understand contemporary strategies, principles and measures for achieving energy efficiency of buildings; use gained knowledge in the scientific research and in engineering practice regarding design, construction and maintenance.

Contents of the subject (teaching units, forms of students' individual work, forms of testing) presented per working weeks in the academic calendar:

Preparatory week	Consultation with supervisor, courses selection.
I week	Introduction. Basic terms regarding energy efficiency from aspects of construction and energy performance of buildings.
II week	Potentials for building energy efficiency increase – low-energy aspects of construction.
III week	Contemporary regulations in domain of construction products and energy efficiency in construction.
IV week	Energy needs regarding building life cycle (built-in energy, energy demands in exploitation, energy during recycling).
V week	Calculation of heat performance and heat flow through elements of building envelope. Flow through opaque and glass surfaces. Flow over soil.
VI week	Aspects of water vapour diffusion through building envelope – calculation; influence on energy efficiency.
VII week	Climate parameters influence on energy performance of buildings. Other calculation parameters.
VIII week	Effects of thermal bridges on energy efficiency – aspects and calculation methods.
IX week	Heat capacity of structure and thermal stability – influence on energy efficiency.
X week	Analysis of calculation parameters of building energy performance depending on construction products and systems.
XI week	Cost optimisation of minimum (required) building energy performance.
XII week	Nearly zero-energy buildings (NZEB).
XIII week	Project task. Seminar paper. (individual work)
XIV week	Project task. Seminar paper. (consultation and review)
XV week	Project task. Seminar paper. (discussion and defence)

Methods of education: teaching (lectures and exercises), in combination with supervised work; consultations; project based teaching/learning; practical work; obtained knowledge and skills presentation

Student's load

Weekly	**In semester**
10 credits x 40/30 = **13.33 hours** Structure: **2** hours of lectures **2** hours of exercises **9.33** hours of individual work	**Lectures and final exam**: (13.33 hours) x 16 = **213.33 hours** **Necessary preparation** before the start of the semester (administration, enrolment, verification): (13.33 hours) x 2 = **26.66 hours** **Total workload for the course**: **10 x 30 = 300 hours** **Additional work** for preparing correction of the final exam, including taking the exam: **0 - 60 hours** (remaining time from the first and the second item to the total workload for the course of 300 hours) **Structure of the workload**: 213.33 hours (lectures and final exam) + 26.66 hours

	(preparation) + 60 hours (additional work)

Students' obligations during the teaching:

- regular attending lectures and other classes or adequate activity in supervised work
- conscientious and individual elaboration of homework and project tasks, as well as realisation of practical work through seminar paper, with systematisation of material and adequately applied scientific research methodology
- individual elaboration of written exam, accompanied by oral discussion
- presenting obtained knowledge during the semester and at the final exam

Literature:

- Hugo Hens: "Building Physics – Heat, Air and Moisture" Fundamentals and Engineering methods with Examples and Exercises, Ernst&Sohn, 2011
- Hugo Hens: "Applied Building Physics – Boundary Conditions, Building Performance and Material Properties", Ernst&Sohn, 2011
- Vilems V., Šild K., Dinter S.: "Građevinska fizika - Priručnik", prevod, Građevinska knjiga, Beograd, 2006
- Jong-Jin Kim: "Qualities, Use, and Examples of Sustainable Building Materials" Fundamentals and Engineering methods with Examples and Exercises, Ernst&Sohn, 2011
- Ray Williams: "Next generation materials and technologies". http://cfsd.org.uk/eco-innovation_workshops/24.09.07_presentations/Ray_Williams_NPL_Next_Generation_Materials&Technologies.pdf
- Osman Attmann: "Green Architecture: Advanced Technologies and Materials", London, New York, Toronto 2010
- Karma Sawyer: "Windows and Building Envelope Research and Development", Road map for Emerging Technologies, Building Technologies Office, U.S. Department of Energy, February 2014.
- A.J. Marszal, et al., Zero Energy Building – A review of definitions and calculation methodologies, Energy Buildings (2011), doi:10.1016/j.enbuild.2010.12.022.
- Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance buildings
- Commission Delegated Regulation (EU) No 244/2012, Annex I: cost-optimal methodology framework.
- MEST EN ISO 50001:2014 Sistemi upravljanja energijom - Zahtjevi sa uputstvom za upotrebu / Energy management systems - Requirements with guidance for use
- MEST EN ISO 13790: Energy performance of buildings - Calculation of energy use for space heating and cooling.
- current literature (scientific papers from international conferences and journals)

Learning outcomes (complied with the outcomes for the study programme):

Knowledge and understanding:

On completion of this course the student will be able to:

- present aspects of energy efficiency in construction, as well as aspects of energy performance of buildings,
- analyse adequacy of calculation procedures and calculation indicators of building energy performance, within life cycle,
- make objective assessment of input parameters for analysis of building energy performance,
- analyse effects of water vapour diffusion and moisture accumulation in building envelope layers,
- assess heat losses and gains of building and formulate thermal balance,
- determine and assess parameters of building thermal stability,
- estimate energy efficiency of building and recommend measures for improvement,
- evaluate technical documentation for improvement of building energy performance.

Transferable / Key skills and other attributes:

- Communication skills: oral defence of seminar paper, manner of expression at written examination.
- Use of information technology: use of software tools in analysis and calculation of energy efficiency.
- Calculation skills: performing calculation operations in analysis and calculation of energy efficiency.
- Problem solving: analyses of energy efficiency and formulation of solutions for improvements.

Forms of tests and evaluation:

Knowledge assessment is continuous during the semester, through pre-exam checks, and in the final exam. In total, student may collect max 100 points. The following is assessed:

- seminar paper and other semester activities (homework etc.) 50%,
- final exam 50%.

The final exam consists of written and oral part. Written part may be realised through project task.
Grades (A, B, C, D, E, F) are adjoined to collected number of points, in line with the Law of Higher Education and study rules at the University of Montenegro.

Name and surname of teacher and associate:

Assoc.Prof. Radmila Sinđić Grebović, Dr-Ing.

Particularities needed to be emphasized for the subject:

Note (if needed):