Nazwa w jęz. angielskim: Energy storage for sustainable energy systems

Dane dotyczące zajęć:
Information on course:

Jednostka oferująca: Wydział Inżynierii Środowiska i Energetyki // dr hab. inż. Jacek Kalina, prof. PŚ
Course offered by: Faculty of Energy and Environmental Engineering // dr hab. inż. Jacek Kalina, prof. PŚ

Język wykładowy:

angielski

Language:

English

Strona WWW:
Course homepage:

Skrócony opis:

Short description:

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.).

Opis:

Description:

The lecture is focused on different electric energy storage technologies and their integration with the energy system. As increasing amounts of renewable energy sources are incorporated into energy systems, the interest in energy storage technologies is growing. Storage is nowadays regarded as an important solution to maintain grid stability and flexibility. Nowadays energy storage provides one of the biggest market opportunities. The sector boasts one of the fastest-moving areas of innovation, with a wide variety of technologies competing fiercely. During the lecture there will be given a review of existing grid-scale energy storage technologies as well as new concepts and emerging technologies will be discussed. Functionality and performance indicators of electric energy storage technologies will be presented and political, economic, social, and environmental implications of energy storage will be discussed. Possibilities of storage integration with different subsystems such as fuel, heating and cooling sectors will be also examined in the context of making benefits out of synergy effects. Additionally key issues of emerging energy storage market, legal regulations, financial performance of projects and business models will be analysed. After this course students will know and understand energy system balance issues and power generation and consumption variability, different technology concepts, principles of operation, various needs, functionalities and key performance indicators of different energy storage systems. Students will understand the complexity of gridconnected energy storage projects and they will learn making decisions in the field. They will be able to compare different storage options and their possible integration pathways. They will be also able to construct and evaluate a simple project in the field of energy storage, identify strengths, weaknesses, opportunities risks and threats for business projects in the field of grid-connected electric energy storage plants.

Number of hours of classes with direct participation of academic teachers or other persons teaching courses and students
Lecture: 15h
Project: 15h
Number of ECTS credits: 3

Literatura:

Bibliography:

1. Lecture notes distributed by lecturer.
2. International Energy Agency: Technology Roadmap. Energy storage. OECD/IEA, 2014, www.iea.org.
3. Robert A. Huggins: Energy Storage. Springer Science and Business Media, LLC 2010. ISBN 978-1-4419-1023-3. DOI 10.1007/978-1-4419-1024-0
4. Ter_Gazarian A.: Energy Storage for Power Systems. Peter Peregrinus Ltd. 1994. ISBN 0 86341 264 5.
5. Melissa C. Lott and Sang-Il Kim. Technology Roadmap: Energy storage. Energy Technology Perspectives, page 64, 2014.
6. Bussar C., Stöcker P., Cai Z., Moraes L., Magnor D,, Wiernes P., van Bracht N., Moser A., Sauer U.D.: Large-scale integration of renewable energies and impact on storage demand in a European renewable power system of 2050-Sensitivity study. Journal of Energy Storage, 6:1–10, 2016.
7. Aneke M., Wang M.: Energy storage technologies and real life applications. A state of the art review. Applied Energy, 179:350–377, 2016.
8. Palizban O., Kauhaniemi K.. Energy storage systems in modern grids - Matrix of technologies and applications. Journal of Energy Storage 6 (2016), pp. 248–259.
9. Budt M., Wolf D., Span R., Yan J.: A review on compressed air energy storage: Basic principles, past milestones and recent developments. Applied Energy 170 (2016) pp. 250–268.
10. Sciacovelli A., Smith D., Navarro H., Li Y., Ding Y.: Liquid air energy storage – Operation and performance of the first pilot plant in the world. Proceedings of the ECOS 2016, June 19-23, 2016, Portorož, Slovenia.
11. Sternberg A., Bardow A.: Power-to-What ? – Environmental assessment of energy storage systems. Energy and Environmental Science. 8 (2) 2015, pp. 389-400.
12. Götz M., Lefebvre J., Mörs F., Mc-Daniel Koch A., Graf F., Bajohr S., Reimert R., Kolb T.: Renewable Power-to-Gas: A technological and economic review. Renewable Energy, 85:1371–1390, 1 2016.
13. Hussein Ibrahim and Adrian Illinca. Techno-Economic Analysis of Different Energy Storage Technologies. Energy Storage - Technologies and Applications, pages 1–40, 2013.

Efekty uczenia się:

Learning outcomes:

1. Knowledge: student knows and understands
K2A_W01: Student understands social, economic, legal and other non-technical conditions of design and operation of energy system and energy storage plants.
K2A_W13, K2A_W15, K2A_W16
Student is able to characterise energy storage processes and their functionality within the energy sector, he/she is aware of possibilities and conditions to store energy as well as of market issues for energy storage.

2. Skills: student can
K2A_U09: Student builds complex models of selected technological processes of energy storage, as well as analyses them by using analytical methods and conducts simulations of those processes.
K2A_U10, K2A_U25:
Student formulates and tests hypotheses related to engineering problems and basic research problems in the field of power engineering as well as formulates and solves an engineering problem related to energy storage
K2A_U15: Student demonstrates the skills of using the principles and methods of thermodynamics, mass and heat transfer, as well as fluid mechanics for design and analysis of energy storage processes.

3. Social competences: student is prepared to
K2A_K03, K2A_K05, K2A_K06
Student cooperates and works in a team, assuming various roles, he/she correctly identifies and solves dilemmas and thinks and acts in a creative and enterprising manner

Metody i kryteria oceniania:

Assessment methods and assessment criteria:

Oral answer, participation in open discussions during lectures, participation in case studies and case study final questionnaire.

Written test, project report.
Observation during participation in case studies and project.

Przynależność do grup przedmiotów w cyklach:
Element of course groups in various terms:

Opis grupy przedmiotów Course group description	Cykl pocz. First term	Cykl kon. Last term
przedmioty obieralne studia stacjonarne stopień studiów – dowolny kierunek studiów – dowolny, semestr dowolny elective courses full-time degree - any field of study - any semester - any	2023/2024	