Code of the course	4606-VP-ES-00008	Name of the course	Polish	**Inteligentna sieć elektroenergetyczna**	
			English	**Smart grid**	
Type of the course	Specialty subject				
Course coordinator	Professor Haitham Abu-Rub		Course teacher	Professor Haitham Abu-Rub	
Implementing unit	Fakulty of elektrical engineering	Scientific discipline / disciplines*	- automation, electronics, electrical engineering and space technologies		
Level of education	Doctoral studies	Semester	Summer, , March 15, 2025 to June 15, 2025		
Language of the course	English				
Type of assessment	pass	Number of hours in a semester	30	ECTS credits	3
Minimum number of participants	10	Maximum number of participants		Available for students (BSc, MSc)	Yes/No

Type of classes		Lecture	Auditory classes	Project classes	Laboratory	Seminar
Number of hours	in a week					
	in a semester	20		10		

* does not apply to the Researcher's Workshop

1. Prerequisites

no prerequisites

2. Course objectives

This course will present smart grid elements, its enabling technologies, current state and the future perspectives. The taught material contains an overview of the smart grid architectural, renewable energy integration opportunities and challenges, power electronics as enabling technology of the smart grid, microgrids structure and control, energy storage, and demand response.

The smart grid encompasses a wide array of technology that has the potential to dramatically improve the reliability, security, and efficiency of the electric grid, offering economic and environmental benefits. The smart grid has been described as the convergence of electric system and information technologies to provide utility customers the enhanced information, services and reliability that are so critical for the coming future.

The objective of this course is to equip the students with an overview of smart grid elements and fundamentals.

3. Course content (separate for each type of classes)

Lecture

1. Smart grid architectural overview.
2. Renewable energy integration: opportunities and challenges.
3. Power electronics as enabling technology of the smart grid.
4. Micro grids: structure and control.
5. Energy storage for smart grid balancing.
6. Smart transportations.
7. Net zero energy building, demand response and demand side management.

8. Advanced metering infrastructure and communication. 9. Information security standards in smart grids. 10. Exams and Review.
Class projects
1. Demand management (demand response and demand side management). 2. Grid connected and islanded AC Microgrid (structure and control). 3. Smart meters and advanced metering infrastructure. 4. Islanding detection techniques. 5. Big data challenges and opportunities for smart grid. 6. SCADA system in smart power grid. 7. EV charging technologies. 8. Current status and future perspectives of energy storage. 9. Virtual utilities in smart grid. 10. Impact of EV integration on power system. 11. Power Quality issues in power electronics dominated grid. 12. Renewable energy dominated grid.

4. Learning outcomes			
Type of learning outcomes	Learning outcomes description	Reference to the learning outcomes of the WUT DS	Learning outcomes verification methods*
Knowledge			
K01	Understand the smart grid concepts and terminology.	SD_W1	Exams
K02	Know the renewable energy integration and micro grid technology.	SD_W2	Exams
K03	Know about energy storage issues in smart grid.	SD_W3	Exams
Skills			
S01	Know the communication technologies, advanced metering infrastructure, and information security standards in smart grids.	SD_U1, SD_U2, SD_U3	Exams
S02			
Social competences			
SC01	Investigate the demand response, demand side management and economy of the smart grids.	SD_K5, SD_K4	Social competencies are assessed based on observation of behaviours and attitudes during the conducted classes

*Allowed learning outcomes verification methods: exam; oral exam; oral test; project evaluation; report evaluation; presentation evaluation; active participation during classes; homework; tests

5. Assessment criteria
The scores for the class attendance, research assignment, and final examination.

6. Literature
Primary references: [1] Smart Grid and Enabling Technologies, Shady S. Refaat, Omar Ellabban, Sertac Bayhan, Haitham Abu-Rub, Frede Blaabjerg, Miroslav M. Begovic, Wiley, 2021. (Primary textbook). [2] Class Material.

7. PhD student's workload necessary to achieve the learning outcomes**		
No.	Description	Number of hours
1	Hours of scheduled instruction given by the academic teacher in the classroom	20
2	Students projects and presentations	10
2	Hours of consultations with the academic teacher, exams, tests, etc.	15
3	Amount of time devoted to the preparation for classes, preparation of presentations, reports, projects, homework	20
4	Amount of time devoted to the preparation for exams, test, assessments	15
	Total number of hours	**80**
	ECTS credits	**3**

** 1 ECTS = 25-30 hours of the PhD students work (2 ECTS = 60 hours; 4 ECTS = 110 hours, etc.)

8. Additional information	
Number of ECTS credits for classes requiring direct participation of academic teachers	2
Number of ECTS credits earned by a student in a practical course	1