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Innovated study program (Master's degree): Renewable Energy Sources and Smart Grids

University of East Sarajevo, Faculty of Electrical Engineering

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Renewable Energy Sources and Smart Grids (curriculum)

O.N.	Subject name	Semester		
		I (IX)		
		LECTURES	EXERCISES	ECTS
1.	Elective subject EN - 1.1	3	2	6.0
2.	Elective subject EN - 1.2	3	2	6.0
3.	Elective subject EN - 1.3	3	2	6.0
4.	Elective subject EN - 1.4	3	2	6.0
5.	Elective subject EN - 1.5	3	2	6.0
	TOTAL	15	10	30

O.N.	Subject name	Semester		
		II (X)		
		LECTURES	EXERCISES	ECTS
6.	Student practice	-	-	6.0
7.	Research work	-	-	6.0
8.	Master thesis	-	-	18.0
	TOTAL	-	-	30

Renewable Energy Sources and Smart Grids (current curriculum)

O.N.	Subject name EN-1.1, EN-1.2, EN-1.3, EN-1.4, EN-1.4, EN-1.5	Semester		
		I (IX)		
		LECTURES	EXERCISES	ECTS
1.	Electricity Market	3	2	6.0
2.	Integration of RES in Power Grids	3	2	6.0
3.	Utilisation of Solar Energy	3	2	6.0
4.	Utilisation of Wind Energy	3	2	6.0
5.	Exploitation and Regulation of Smart Grids	3	2	6.0
6.	Energy Storage Systems	3	2	6.0
7.	Energy Efficiency	3	2	6.0
8.	Measurement and Monitoring Systems in Smart Grids	3	2	6.0
9.	System Modelling and Simulation	3	2	6.0
10.	IoT Infrastructure in Smart Grids	3	2	6.0
11.	Power Electronics Converters in Smart Grids	3	2	6.0
	TOTAL	33	22	66

Renewable Energy Sources and Smart Grids (innovated curriculum)

O.N.	Subject name EN-1.1, EN-1.2, EN-1.3, EN-1.4, EN-1.4, EN-1.5	Semester		
		I (IX)		
		LECTURES	EXERCISES	ECTS
1.	Electricity market	3	2	6.0
2.	Integration of RES in Power Grids	3	2	6.0
3.	Utilisation of Solar Energy	3	2	6.0
4.	Utilisation of Wind Energy	3	2	6.0
5.	Exploitation and Regulation of Smart Grids	3	2	6.0
6.	Energy Storage Systems	3	2	6.0
7.	Energy Efficiency	3	2	6.0
8.	Measurement and Monitoring Systems in Smart Grids	3	2	6.0
9.	System Modelling and Simulation	3	2	6.0
10.	IoT Infrastructure in Smart Grids	3	2	6.0
11.	Power Electronics Converters in Smart Grids	3	2	6.0
	TOTAL	33	22	66

Renewable Energy Sources and Smart Grids (innovated curriculum)

O.N.	Subject name EN-1.1, EN-1.2, EN-1.3, EN-1.4, EN-1.4, EN-1.5	Semester		
		I (IX)		
		LECTURES	EXERCISES	ECTS
1.	Digital Relay Protection	3	2	6.0
2.	Microgrids	3	2	6.0
3.	Electric Vehicles in Smart Grids	3	2	6.0
	TOTAL	9	6	18

Electricity Market (innovated course)

Number of lessons/teaching workload (weekly)			Individual student workload (in hours per a semester)			Student workload coefficient S_o
L	AE	LE	L	AE	LE	S_o
3	2	0	63	42	0	1.4
total teaching workload (in hours, per semester) W= 3*15 + 2*15 + 0*15 =75 hours			total student workload (in hours, per semester) T= 3*15*S_o + 2*15*S_o + 0*15*S_o = 105 hours			
Total workload of the subject (teaching + student): In_{opt}= W + T = 75 + 105 = 180 hours per semester						

Learning outcomes	Upon completion of the course the student should be able to: 1. Describe the principles of organizing electricity markets. 2. Describe flexible consumers and prosumers. 3. Describe the basic methods of managing financial risks in electricity markets. 4. Perform price calculations in small and large power systems. 5. Comprehend local electricity markets. 6. Understanding of different energy policies. 7. Formulate market simulation problems using an appropriate mathematical model.

Teaching methods	Lectures, auditory exercises, homework, seminar work

Electricity Market (innovated course)

Subject content per weeks	1. A review of relevant topics from microeconomics. 2. Electricity industry overview. 3. Wholesale and retail electricity markets. o. Representing network constraints: nodal pricing, o. Representing network constraints: zonal pricing 4. Representing network constraints: nodal and zonal pricing. o. Efficient investment in generation and consumption assets. 5. Market-based investment in generation, network and consumption assets. o. Efficient investment in network assets. o. Regulation of transmission investment. 6. Risk management in electricity markets. 7. Market power: theory and practice. o. Modelling and forecasting electricity prices: Regression. o. Modelling and forecasting electricity prices: Cointegration. o. Modelling and forecasting electricity prices: Volatility, VaR, Quantile methods. o. Modelling and forecasting electricity prices: Regime-switching. 8. Modelling and forecasting electricity prices (part I) 9. Modelling and forecasting electricity prices (part II) 10. Energy policies. 11. Demand response programs. 12. Prosumers and self-consumption schemes. 13. Energy communities. 14. Local electricity markets. 15. Demand and distributed energy sources aggregators.

Electricity Market (innovated course)

Compulsory literature			
Author(s)	**Publication title, publisher**	**Year**	**Pages (from-to)**
D. R. Biggar, M. R. Hesamzadeh	The Economics of Electricity Markets	2014	/
J. Lin, F. H. Magnago	Electricity Markets: Theories and Applications	2017	/
Additional literature			
Author(s)	**Publication title, publisher**	**Year**	**Pages (from-to)**
T. Pinto, Z. Vale, S. Widergren	Local Electricity Markets	2021	/

	Type of student work evaluation	**Points**	**Percentage**
Obligations, forms of knowledge assessment and grading	Pre-examination obligations		
	attendance at lectures	10	10 %
	auditory exercises	30	30 %
	seminar work	30	30 %
	final exam (oral)	30	30 %
	TOTAL	100	100 %

Measurement and Monitoring Systems in Smart Grid (innovated course)

Number of lessons/teaching workload (weekly)			Individual student workload (in hours per a semester)			Student workload coefficient S_o
L	AE	LE	L	AE	LE	S_o
3	1	1	63	21	21	1.4
total teaching workload (in hours, per semester) W= 3*15 + 1*15 + 1*15 =75 hours			total student workload (in hours, per semester) T= $3*15*S_o + 1*15*S_o + 1*15*S_o$ = 105 hours			
Total workload of the subject (teaching + student): In_{opt}= W + T = 75 + 105 = 180 hours per semester						

Learning outcomes	Upon completion of the course the student should be able to: 1. Understand the requirements for automation in power systems. 2. Understand the basics of SCADA systems and their applications in power systems. 3. Understand the concept of control in distribution systems. 4. Understand advanced metering architectures in smart grids. 5. Design and implement advanced metering infrastructure (AMI). 6. Analyze data from smart meters to optimize smart grid operation.

Teaching methods	Lectures, auditory, laboratory exercises, seminar work

Measurement and Monitoring Systems in Smart Grid (innovated course)

Subject content per weeks	1. Introduction to power system automation. 2. Fundamentals of SCADA systems (part 1). 3. Fundamentals of SCADA systems (part 2). 4. Applications of SCADA in power systems. o. Types of communications in SCADA systems. o. SCADA and protocols in smart grids. 5. Control and management centers in smart grids. 6. Distribution management systems (DMS). 7. Smart meters: technology and applications. 8. Advanced metering infrastructures (AMI) in smart grids. 9. Communication protocols for AMI. 10. Data management and privacy in AMI systems. 11. Advanced control strategies in smart grids. 12. Real-time monitoring and control in smart grids. 13. Demand management and flexibility in smart grids. 14. Energy management in smart buildings. 15. Future trends in smart grids and AMI.

Measurement and Monitoring Systems in Smart Grid (innovated course)

Compulsory literature			
Author(s)	**Publication title, publisher**	**Year**	**Pages (from-to)**
M. S. Thomas, J. D. Mc Donald	Power System SCADA and Smart Grid	2015	/
V. K. Sood, M. Biswal, S. Sarangi, H.H. Alhelou	Smart Metering Infrastructure: Methodologies, Applications, and Challenges	2024	/
K.S.K Weranga, S. Kumarawadu, D. P. Chandima	Smart Metering Design and Applications	2013	/
Additional literature			
Author(s)	**Publication title, publisher**	**Year**	**Pages (from-to)**
E. Hossain, Z. Han, H. V. Poor	Smart Grid Communications and Networking	2012	/

	Type of student work evaluation	Points	Percentage
Obligations, forms of knowledge assessment and grading	Pre-examination obligations		
	attendance at lectures	10	10 %
	laboratory exercises	20	20 %
	homework	10	10 %
	seminar work	30	30 %
	final exam (oral)	30	30 %
	TOTAL	100	100 %

Digital Relay Protection (new course)

Number of lessons/teaching workload (weekly)			Individual student workload (in hours per a semester)			Student workload coefficient S_o
L	AE	LE	L	AE	LE	S_o
3	1	1	63	21	21	1.4
total teaching workload (in hours, per semester) W= 3*15 + 1*15 + 1*15 =75 hours			total student workload (in hours, per semester) T= 3*15*S_o + 1*15*S_o + 1*15*S_o = 105 hours			
Total workload of the subject (teaching + student): In_{opt}= W + T = 75 + 105 = 180 hours per semester						

Learning outcomes	Upon completion of the course the student should be able to: 1. Comprehend digital relay principles. 2. Design and analyze protection algorithms. 3. Configure digital relays for protection schemes. 4. Test and commission digital relay systems. 5. Analyze and interpret fault records.

Teaching methods	Lectures, auditory, laboratory exercises, seminar work

Digital Relay Protection (new course)

Subject content per weeks	1. Overview of power system protection. 2. Fundamental principles of digital relays. 3. Protection algorithms in digital relays. 4. Design and simulation of protection algorithms. 5. Overview of digital protection relays for overhead lines. 6. Relay settings and configuration for overcurrent protection. 7. Relay settings and configuration for earth fault protection. 8. Relay settings and configuration for overvoltage and undervoltage protection. 9. Digital protection of distribution networks with distributed generation. 10. Wide-area digital protections in smart grids. 11. Communication protocols in digital relays. 12. Testing and commissioning of digital relays. 13. Fault analysis and event recording. 14. Troubleshooting and maintenance of digital relays. 15. Security and reliability in digital relay systems.

Digital Relay Protection (new course)

Compulsory literature			
Author(s)	**Publication title, publisher**	**Year**	**Pages (from-to)**
S. H. Horowitz, A. G. Phadke	Power System Relaying (4th Edition)	2013	/
S. K. Salman, A.T. Johns	Digital Protection for Power Systems (2nd Edition)	2022	/
Additional literature			
Author(s)	**Publication title, publisher**	**Year**	**Pages (from-to)**
V. Gurevich	Digital Protective Relays: Problems and Solutions (1st Edition)	2019	/
M. Kezunovic, J. Ren, S. Lotfifard	Design, Modeling and Evaluation of Protective Relays for Power Systems	2016	/

	Type of student work evaluation	Points	Percentage
Obligations, forms of knowledge assessment and grading	Pre-examination obligations		
	attendance at lectures	10	10 %
	laboratory exercises	30	30 %
	seminar work	30	30 %
	final exam (oral)	30	30 %
	TOTAL	100	100 %

Microgrids (new course)

Number of lessons/teaching workload (weekly)			Individual student workload (in hours per a semester)			Student workload coefficient S_o
L	AE	LE	L	AE	LE	S_o
3	1	1	63	21	21	1.4
total teaching workload (in hours, per semester) W= 3*15 + 1*15 + 1*15 =75 hours			total student workload (in hours, per semester) T= $3*15*S_o + 1*15*S_o + 1*15*S_o$ = 105 hours			
Total workload of the subject (teaching + student): In_{opt}= W + T = 75 + 105 = 180 hours per semester						

Learning outcomes	Upon completion of the course the student should be able to: 1. Comprehend fundamental microgrid concepts. 2. Design distributed energy systems for microgrids. 3. Analyze power flow and microgrid stability. 4. Develop and implement microgrid control strategies. 5. Integrate renewable energy sources into microgrids.

Teaching methods	Lectures, auditory, laboratory exercises, seminar work

Microgrids (new course)

Subject content per weeks	1. Introduction to microgrids. 2. Microgrid architectures and configurations. 3. Distributed energy resources (DERs) in microgrids. 4. Power flow analysis in microgrids. 5. Stability analysis of microgrids. 6. Control strategies for microgrids (part 1). 7. Control strategies for microgrids (part 2). 8. Energy management systems (EMS) for microgrids. 9. Renewable energy integration in microgrids (part 1). 10. Renewable energy integration in microgrids (part 2). 11. Interoperability between microgrids and main grid. 12. Economic viability and business models for microgrids. 13. Cybersecurity in microgrids. 14. Future trends and technologies in microgrids. 15. Microgrids in electricity markets.

Microgrids (new course)

Compulsory literature			
Author(s)	**Publication title, publisher**	**Year**	**Pages (from-to)**
J. B. Holm-Nielsen, S. Padmanaban, S. Chenniappan, S. Palanisamy	Microgrid Technologies	2021	/
J. M. Guerrero, R. Kandari	Microgrids: Modeling, Control, and Applications	2021	/
Additional literature			
Author(s)	**Publication title, publisher**	**Year**	**Pages (from-to)**
N. Hatziargyriou	Microgrids: Architectures and Control	2014	/

	Type of student work evaluation	**Points**	**Percentage**
Obligations, forms of knowledge assessment and grading	Pre-examination obligations		
	attendance at lectures	10	10 %
	laboratory exercises	20	20 %
	seminar work	40	40 %
	final exam (oral)	30	30 %
	TOTAL	100	100 %
Web page			
Certification date			

Electric Vehicles in Smart Grids (new course)

Number of lessons/teaching workload (weekly)			Individual student workload (in hours per a semester)			Student workload coefficient S_o
L	AE	LE	L	AE	LE	S_o
3	1	1	63	21	21	1.4
total teaching workload (in hours, per semester) W= 3*15 + 1*15 + 1*15 =75 hours			total student workload (in hours, per semester) $T= 3*15*S_o + 1*15*S_o + 1*15*S_o = 105$ hours			
Total workload of the subject (teaching + student): $In_{opt} = W + T = 75 + 105 = 180$ hours per semester						

Learning outcomes	Upon completion of the course the student should be able to: 1. Understand the basic physical principles of electric vehicles operation. 2. Understand the working principles of various power electronics converters and their control structures in electric vehicles. 3. Understand the working principles of various electric drives and their control structures in electric vehicles. 4. Understand the working principles of energy storage systems (batteries) and their management systems in electric vehicles. 5. Learn basics of different software tools for modelling, analysis and simulation of electric vehicles.

Teaching methods	Lectures, auditory, laboratory exercises, seminar work

Electric Vehicles in Smart Grids (new course)

Subject content per weeks	1. Introduction of electric vehicles. 2. Classification of EV, challenges, overview of various developed technologies. 3. Role and significance of power electronics converters in electric vehicles. 4. Review of power converters topologies in electric vehicles. 5. Types of electric motors/drives in electric vehicles. 6. DC motor drives. 7. Energy sources in electric vehicles. 8. Basic parameters for evaluating energy storage systems 9. Power batteries as the main energy storage part in electric vehicles. 10. Battery chargers/dischargers in electric vehicles. Review of charging topologies. 11. Key Technologies of Battery Management System (BMS). 12. Electric vehicle charging infrastructure and its role in power grid. 13. Impact of electric vehicles on the grid. 14. Electric vehicles as energy generators to grid. 15. Modelling and simulation of impact of electric vehicles on grid – charging from grid and power generation from vehicles to grid.

Electric Vehicles in Smart Grids (new course)

Compulsory literature			
Author(s)	**Publication title, publisher**	**Year**	**Pages (from-to)**
K. T. Chau	Electric Vehicle Machines and Drives. Design, Analysis and Application, John Wiley & Sons	2015	/
Kumar L. Ashok, Alexander S. Albert	Power Converters for Electric Vehicles, CRC Press, Taylor & Francis Group, LLC	2021	/
Additional literature			
Author(s)	**Publication title, publisher**	**Year**	**Pages (from-to)**
D. Kishan, R. Kannan, B D. Reddy, P. Prabhakaran	Power Electronics for Electric Vehicles and Energy Storage. Emerging Technologies and Developments. CRC Press – Taylor and Francis Group	2023	/
S. Yang, X. Liu, S. Li, C. Zhang	Advanced Battery Management System for Electric Vehicles. Key Technologies on New Energy Vehicles. Springer	2023	/

	Type of student work evaluation	Points	Percentage
Obligations, forms of knowledge assessment and grading	Pre-examination obligations		
	attendance at lectures	10	10 %
	laboratory exercises	20	20 %
	seminar work	40	40 %
	final exam (oral)	30	30 %
	TOTAL	100	100 %

Thank you for your attention!