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Content of new/innovated study programs in Western Balkans countries (WB)

University of Mostar
Faculty of Mechanical Engineering, Computing and Electrical Engineering

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Ivan Bevanda
Higher Teaching Asisstant

Reasons for focusing on renewable energy

Market Needs

- Growing Demand: Increasing global demand for renewable energy professionals.
- Industry Alignment: Aligns with industry trends towards sustainable energy solutions.

Renewable Energy Potential in Bosnia and Herzegovina

- Abundant Resources: Significant solar, wind, and hydro energy potential
- Strategic Location: Ideal geographic conditions for harnessing renewable energy

Educational Advancements

- Modern Curriculum: Building on the existing modern courses introduced in 2016 and revised in 2022.
- Specialization Opportunities: Allows students to specialize in renewable energy systems through targeted electives.

Reasons for focusing on renewable energy

Electrical Engineering Program Evolution

- Introduced in 2016: Relatively new program
- First revision in 2022: Modernization of curriculum
- Current approach: Targeted improvements rather than complete overhaul

Existing Modern Curriculum

- Already includes contemporary subjects
- Aligns with current industry trends and technologies

Strategic Curriculum Enhancement

- Focus on renewable energy specialization
- Introduction of new elective subjects
- Upgrading existing courses

Content of the study programme – graduate study (current curriculum)

Study direction : Control systems and automation

Year of study: I Study direction : Control systems and automation Winter semester									
Course code	Course name	Teaching hours			I. Total teaching	II. Hours of practice	III. Independent work	Total hours (I.+II.+III.)	ECTS
		p	v	s					
FSREEM101	Fundamentals of robotics	3	1	0	60	0	120	180	6
FSREEM102	Syntesis of control systems	3	1	0	60	0	120	180	6
FSREEM103	Control of electrical drives	3	1	0	60	0	120	180	6
	Elective nontechnical course							120	4
	Elective course I							120	4
	Elective course II							120	4
	Total	9	3	0					18
ECTS for obligatory courses									12
ECTS for elective courses									
ECTS TOTAL									30

Year of study: I Study direction : Control systems and automation Summer semester									
Course code	Course name	Teaching hours			I. Total teaching	II. Hours of practice	III. Independent work	Total hours (I.+II.+III.)	ECTS
		p	v	s					
FSREEM201	Automation of processes and power plants	3	1	0	60	0	120	180	6
FSREEM202	Fundamentals of process identification	3	1	0	60	0	120	180	6
FSREEM203	Project management	2	0	0	30	0	90	120	4
	Elective course I							120	4
	Elective course II							120	4
	Elective course III							120	4
FSREEM204	Seminar I	0	0	2	0	0	60	60	2
	Total	8	2	2					30
ECTS for obligatory courses									18
ECTS for elective courses									12
ECTS TOTAL									30

Study direction : Electrical power engineering

Year of study: I Study direction : Electrical power engineering Winter semester									
Course code	Course name	Teaching hours			I. Total teaching	II. Hours of practice	III. Independent work	Total hours (I.+II.+III.)	ECTS
		p	v	s					
FSREEM104	Distribution network and distributed production	3	2	0	75	0	105	180	6
FSREEM105	Power markets and economics in power engineering	3	1	0	60	0	120	180	6
FSREEM103	Control of electrical drives	3	1	0	60	0	120	180	6
	Elective nontechnical course							120	4
	Elective course I							120	4
	Elective course II							120	4
	Total	9	4	0					18
ECTS for obligatory courses									12
ECTS for elective courses									
ECTS TOTAL									30

Year of study: I Study direction : Electrical power engineering Summer semester									
Course code	Course name	Teaching hours			I. Total teaching	II. Hours of practice	III. Independent work	Total hours (I.+II.+III.)	ECTS
		p	v	s					
FSREEM201	Automation of processes and power plants	3	1	0	60	0	120	180	6
FSREEM205	Dynamics of power systems	3	1	0	60	0	120	180	6
FSREEM203	Project management	2	0	0	30	0	90	120	4
	Elective course I							120	4
	Elective course II							120	4
	Elective course III							120	4
FSREEM204	Seminar I	0	0	2	0	0	60	60	2
	Total	8	2	2					30
ECTS for obligatory courses									18

Content of the study programme – graduate study (elective courses)

Šifra	Naziv kolegija	P+V+L	Ispit	ECTS
	Adaptive and Robust Control	30+0+0	1	4
	Intelligent Control Systems	30+0+0	1	4
	Mechatronic Systems	30+0+0	1	4
	Mobile Robotics	30+0+0	1	4
	Nonlinear Control Systems	30+0+0	1	4
	Electronic Systems Design	30+0+0	1	4
	Technical Mechanics	30+0+0	1	4
	Electromagnetic Compatibility	30+0+0	1	4
	Graphical Programming	30+0+30	1	4
	Energy storage	30+0+0	1	4
	Energy, Environment and Sustainable Development	30+0+0	1	4
	Special Protection Systems	30+0+15	1	4
	Basics of Entrepreneurship**	30+0+0	1	4
	Financial evaluation of energy investment projects**	30+0+15	1	4

Šifra	Naziv kolegija	P+V+L	Ispit	ECTS
	Low-voltage electrical installations and lighting	30+15+15	1	4
	High Voltage Technology	30+15+0	1	4
	Energy Conversion	30+15+0	1	4
	Overhead Lines and Cables	30+0+15	1	4
	Monitoring and Remote Control of the Power System	30+0+15	1	4
	Quality of Electric Power Supply	30+0+0	1	4
	Technical Mechanics	30+0+0	1	4
	Electromagnetic Compatibility	30+0+0	1	4
	Graphical Programming	30+0+30	1	4
	Energy storage	30+0+0	1	4
	Energy, Environment and Sustainable Development	30+0+0	1	4
	Special Protection Systems	30+0+15	1	4
	Basics of Entrepreneurship**	30+0+0	1	4
	Financial evaluation of energy investment projects**	30+0+15	1	4

Goals of NEST4WB project

Curriculum Enhancement

- Upgrading existing course: Renewable Energy Sources (3rd year undergraduate)
- New elective: Photovoltaic Power Plants (1st year graduate)
- New elective: Smart Wind Energy Systems and Grid Integration (1st year graduate)

New Renewable Energy Laboratory

- Practical training and research opportunities
- Support for master's thesis projects
- Exposure to industry-relevant technologies and equipment

New Specialization Path

Specialization in Renewables

- Students can now specialize in renewable energy technologies
- Progressive learning path from basics to advanced topics

Learning Path

1. Fundamentals: Renewable Energy Sources (3rd year)
2. Bachelor's Thesis: Focus on renewable energy topics
3. Specialized Electives: Choose PV Power Plants and Smart Wind Energy Systems
4. Master's Thesis: Focus on renewable energy topics
5. Professional Internship: Work in the new Renewable Energy Laboratory or Company specialised in renewable energy

Renewable Energy Systems

- Be able to classify renewable energy sources according to the primary energy source (water mass, solar radiation, wind, biomass, geothermal energy)
- Know the basics of converting wind energy into mechanical energy in a wind turbine
- Know the basic construction elements of a wind turbine and the basic way of managing a wind turbine and wind power plant
- Understand the principles of integrating wind power plants into the power system
- Explain the photovoltaic effect, know the equivalent model and the current-voltage characteristic of the photovoltaic panel, and the ways of connecting photovoltaic panels into photovoltaic fields
- Know the principles of operation of electronic converters for photovoltaic fields in grid-connected and island modes
- Know the principles of integrating photovoltaic power plants into the power grid

Competences to be added

- Know the basics of Internet of Things (IoT) technology and its role in monitoring and controlling renewable energy systems
- Be able to integrate smart grid technologies to enhance the efficiency and reliability of power distribution network
- Understand the concepts and implementation of energy-efficient technologies in both residential and industrial applications
- Understand the role of big data analytics in predicting and optimizing energy consumption patterns
- Be familiar with advanced metering infrastructure (AMI) and its role in smart energy management

Photovoltaic power plants

- The aim of the course is to acquire basic knowledge about components and systems for photovoltaic conversion of electricity. Students learn about the characteristics of solar radiation, the physical basis of work and the basic parameters of a solar cell, the materials that are currently used to make solar cells. In addition to conventional ones, students are also introduced to potential concepts and technologies that are included in the so-called the third generation of solar cells. Finally, students will learn to design a simple networked photovoltaic system and calculate the expected production of electricity.

Competences to be acquired

- 1. calculate the components of solar radiation on an inclined surface,
- 2. explain the physical principle of solar cell operation,
- 3. compare existing technologies for the production of solar cells,
- 4. design a networked photovoltaic system,
- 5. calculate the expected electricity production from the photovoltaic system.

Advanced competences to be gained

1. IoT Integration for Photovoltaic Systems:

- **Competence in IoT Communication Protocols:** Understanding and applying communication protocols (e.g., MQTT, CoAP) for integrating IoT devices in photovoltaic power plants.
- **IoT-based Predictive Maintenance:** Skills in using IoT sensors and devices for predictive maintenance of photovoltaic systems to monitor performance and detect potential failures before they occur.

2. Smart Grid Technologies:

- **Smart Grid Integration:** Ability to integrate photovoltaic power plants with smart grid technologies, including grid-tied inverters, advanced metering infrastructure (AMI), and demand response systems.
- **Energy Management Systems (EMS):** Knowledge of designing and implementing energy management systems to optimize the operation and energy distribution in smart grids.

3. Energy Efficiency:

- **Energy Auditing and Optimization:** Ability to conduct energy audits and implement optimization strategies to improve the energy efficiency of photovoltaic power plants.
- **Advanced Photovoltaic Materials and Technologies:** Understanding of the latest advancements in photovoltaic materials (e.g., perovskite solar cells) and their impact on energy efficiency.
- **Virtual Power Plants (VPP):** Understanding the concept and implementation of virtual power plants that aggregate distributed energy resources, including photovoltaic systems, to act as a single power plant.

Smart Wind Energy Systems and Grid Integration

The "Smart Wind Energy Systems and Grid Integration" course focuses on advanced technologies and strategies for integrating wind energy into modern power systems. This elective subject, offered in the first year of graduate study, builds upon the foundational knowledge gained in the Renewable Energy Sources course.

Course Content

Wind Turbine Technologies

Students will explore various wind turbine generator systems, including fixed speed, variable speed, and semi-variable speed operations. The course will cover the evolution of wind turbine technology and associated power electronics, emphasizing their suitability for smart grid integration.

Smart Grid Integration

The course will delve into the challenges and solutions for integrating wind energy into smart grids. Topics will include:

- Grid stability and reliability issues related to wind energy's intermittent nature
- Advanced control techniques for managing wind power variability
- Demand response programs and their impact on wind energy integration

Hybrid Systems

Students will study hybrid multi-source power systems that combine wind turbines with other renewable and conventional energy sources[13]. This includes:

- Integration of wind with photovoltaic, fuel cells, and energy storage systems
- Optimization of hybrid systems for improved reliability and efficiency

Advanced Control Strategies

The course will cover cutting-edge control methods such as:

- Model Predictive Control (MPC) for wind turbine generation
- Adaptive control techniques for Load Frequency Control
- Multi-Objective Particle Swarm Optimization (MOPSO) for optimal system management

Data-Driven Approaches

Students will learn about the application of data analytics and artificial intelligence in wind energy systems:

- Big data utilization for wind farm optimization
- Machine learning techniques for forecasting and system optimization

Energy Storage Integration

The course will emphasize the critical role of energy storage in wind power systems:

- Battery Energy Storage Systems (BESS) for managing wind power variability
- Security-Constrained Unit Commitment (SCUC) models incorporating energy storage

Practical Component

The course will include hands-on experience through:

- Simulation exercises using software like MATLAB/SIMULINK
- Case studies on real-world wind energy integration projects
- Potential laboratory work in the new Renewable Energy Laboratory

By completing this course, students will gain comprehensive knowledge of modern wind energy systems and their integration into smart grids, preparing them for careers in the rapidly evolving renewable energy sector.

Laboratory equipment: Hybrid renewable energy trainer

Hybrid energy module

Name	Characteristics	Power
PV modules	4 kom x 285 Wp polycrystal	1140 W
Wind turbine	Generator axial flux PMG 48 VAC at 350 RPM rotor diameter 1320 mm	1000 W
Total installed power		2140 W

Laboratory software suite

Solar Energy Modeling

- PVsyst: Industry-standard for PV system design and simulation
- PVSOL: Comprehensive 3D planning and simulation for PV systems
- SAM (System Advisor Model): Free tool for performance and financial modeling

Wind Energy Modeling

- WindPRO: Leading software for wind farm design and planning
- WAsP (Wind Atlas Analysis and Application Program): Industry-standard wind resource assessment
- OpenWind: Open-source wind farm layout optimization tool

Hybrid System Design

- HOMER Pro: Optimization software for grid-connected and off-grid power systems
- RETScreen: Clean energy management software for feasibility analysis

Laboratory software suite

Grid Integration Tools

- ETAP: Power system analysis and operation software
- PowerFactory: Dynamic modeling for grid integration studies

General Purpose Tools

- MATLAB/Simulink: Versatile platform for system modeling and simulation
- Python with renewable energy libraries: Open-source option for custom modeling

- This diverse software suite will equip students with hands-on experience using industry-standard tools, enhancing their skills in renewable energy system design, analysis, and optimization
- The inclusion of both commercial and open-source options provides a comprehensive learning environment for students to explore various aspects of solar and wind energy modeling

Development of a New Laboratory for Renewable Energy Systems

- **Objective:** To establish a state-of-the-art laboratory for renewable energy systems that will enhance the educational and research capabilities of the faculty. This facility will provide students with hands-on experience in various renewable energy technologies, primarily focusing on solar and wind energy systems.
- **Purpose:** The equipment to be procured for this laboratory will serve dual purposes:

1. **Educational:** To offer students practical exposure and understanding of renewable energy systems through various exercises and experiments.
2. **Academic Research:** To facilitate cutting-edge research in renewable energy technologies, smart grids, and the integration of IoT in renewable energy systems.

- **Competences Gained by Students:** Students will acquire a range of competences, including but not limited to:
- Understanding the fundamentals of photovoltaic (PV) and wind energy systems.
- Practical skills in measuring and analyzing solar irradiation, PV panel characteristics, and wind turbine outputs.
- Competence in regulating and managing energy storage systems.
- **Advanced Competences:**
- **Smart Grids:** Students will learn about the integration of renewable energy sources into smart grids, focusing on efficient and reliable energy distribution.
- **IoT in Renewables:** Understanding how IoT technologies can be utilized to optimize the performance and monitoring of renewable energy systems.
- **Energy Efficiency:** Ability to conduct energy audits and implement optimization strategies to improve the energy efficiency of photovoltaic power plants and understanding of the latest advancements in photovoltaic materials (e.g., perovskite solar cells) and their impact on energy efficiency.

Purchased Equipment

Sum	Equipment	Computer CPU INT Core i5 12400F MBO MBO 1700 AS PRIME H610M-K D4 CPU CPU INT Core i5 12400F RAM MEM DDR4 16GB 3200Mhz Premier AD VGA VGA AS GT730-4H-SL-2GD5 1 HDD/SDD SSD 512GB AD SU650 SATA 3D Nand 2.5" CASE CAS MS ELEMENT M310 computer case PSU PSU MS BASE M500 supply unit KEYBOARD+MOUSE Warranty: 24 months	11	4900.00	
SUM	Equipment	Modularni laboratorijski sustav za obnovljive izvore energije prilagođen edukaciji- Renewable Energy Trainer - Wind, Solar: Measurement of solar irradiation Measurement of the voltage of the photovoltaic panel at no-load Measurement of the short circuit current of the photovoltaic module Graph of current – voltage of the photovoltaic panel Measurement of voltage and current of the panel in overload Regulation and charge of the battery DC solar plant AC installation Examination of the Relationship between Turbine Speed and Wind Turbine Output Voltage (No-load Operation) Examination of the Relationship between Turbine Speed and Wind Turbine Output Voltage (Loaded Operation) Examining Wind Turbine Controller Effect on the Relation Between Turbine Speed and Turbine Output Voltage (No Load Operation) Examining Wind Turbine Controller Effect on the Relation Between Turbine Speed and Turbine Output Voltage (Loaded Operation) Examination of Wind Turbine Output Voltage Examination of Wind Turbine Output Voltage with DAQ Module Examination of Wind Energy System	1	25600.00	

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Thank you for your attention!