INTERDISCIPLINARY ASPECTS OF INDUSTRY INNOVATIONS USE IN STUDY PROCESS AT UNIVERSITY

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Abstract

The paper provides an analysis and exposes the need for more intensive use of ICT in combination with modern sources of renewable energy for efficient implementation of modern control and management technologies. Some interdisciplinary aspects of renewable energy and IC technologies use at universities are analyzed. The objective of this paper is to outline the original approach to the connection of the study process at university in the field of applied knowledge and skills in scope of energy informatics with use of novel principles of energy use for infrastructure support and development. The use of innovation in energy and computer technologies for university infrastructure may guarantee the construction of very effective base for providing of practical training and R&D activities for students. Justification of the role of interdisciplinarity in form of energo informatics as provider of industry innovations use in study process at university is one of the tasks on the path to objective. Critical analysis of a concept, using the literature as data and hybrid descriptive method were implemented for assigned tasks realization. Concept of interdisciplinary approach at university in scope of innovative essence of energo informatics in theoretical and practical spheres will open not only new horizons in educational process, but also provide a new technological solutions implementation in university study environment. The activities described in this article should be realized in the design and development of a complex, reliable, robust, and sustainable system for the interaction between different disciplines in the scientific field, in the field of education, and also in the field of application of modern energy and IC technologies to ensure the sustainability of the university infrastructure.
Key words: Energy informatics, University, Interdisciplinarity, Smart infrastructure.

Introduction

The energy sector is facing increasing challenges and is undergoing significant changes that increase its complexity and have led to the need for innovative energy management strategies. Currently, 85% of the world population utilizes electricity, with coal representing the main resource for 40% of the world's electricity (Bhattacharjee, 2019). Coal also produces 70% of the carbon dioxide emissions (CO2) from the generation of electricity (World Nuclear Association, 2022). The EU has set long-term goals of reducing greenhouse gas emissions by 80–95% when compared to 1990 levels by the year 2050. With the so-called "European Green Deal," the EU aims to be climate-neutral by 2050. Climate neutral means an economy with net-zero greenhouse gas emissions, which will create the need for decarbonization of the energy system while at the same time ensuring the security and safety of energy supply (European Union (2050) Long term strategy, 2019). Moreover, in September 2015, the United Nations General Assembly formally adopted the Agenda for Sustainable Development (United Nations: Sustainable development Agenda, 2015). This comprises a set of 17 Sustainable Development Goals (SDGs), to address the global challenges the world is facing, including those related to poverty, inequality, climate change, environmental degradation, peace and justice. Among all 17 goals, there are a several that are deeply connected to challenges in the education, energy sector and industry innovation and infrastructure. These include: quality education (SDG 4); ensuring access to affordable, reliable, sustainable and modern energy (SDG 7); building resilient infrastructure, promoting sustainable industrialization and fostering innovation (SDG 9); partnerships for the goals achievement (SDG 17) (United Nations: Sustainable Development Goals, 2015).

It is clear, that growing energy generation and consumption together with renewable energy electrical systems development along with fostering innovations in ICT sphere, social aspects in scope of quality education are the major worldwide concerns. Structurally society major concerns are presented in (Fig.1). These concerns need to be directed comprehensively in order to properly achieve the long-term goals of the EU as well as in the broader sense – Sustainable Development Goals.

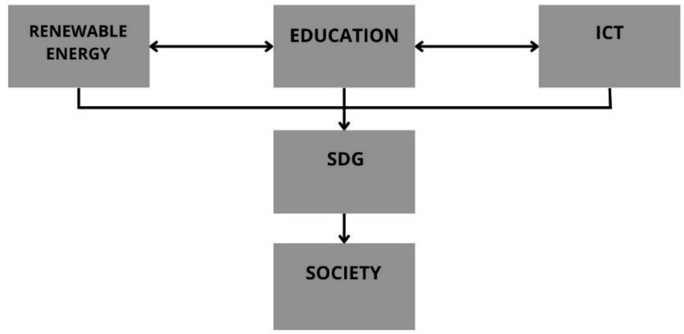

Fig. 1. Society major concerns
Source: composed by author.

An interdisciplinary approach is a co-construction collaborative process that aims at integrating the perspectives of different disciplines, efforts in scope of education, industry innovations in order to achieve a synthesis of knowledge, and skills as well as provide a holistic understanding of the problem (Mallaband, 2017). Thus, interdisciplinarity is a prime example of the changes that are needed in energy research to address the challenges of today's complex world and achieve the wide range of goals associated with further energy innovation. Indeed, the transition of energy systems to sustainable development poses many challenges. The socio-educational, technical, and economic nature of most of these problems necessitates interdisciplinary collaboration. By incorporating knowledge and perspectives from various disciplines, holistic approaches can provide a more comprehensive understanding of the complex interactions between technology, society, and quality education. This can require more effective interdisciplinary interventions and solutions to address the challenges and transitions in power, electrical energy and ICT systems. Within the interdisciplinary approach outlined above, the new field of energy informatics plays an important role: it includes various disciplines, emerging new information and communication technologies to solve socio-educational, technical and economic problems of energy systems. Thus, energy informatics is an integrative field that helps to make energy systems more sustainable. The imperative objective of energy informatics is to make energy systems more efficient, effective, safe, secure, economical, and clean by utilizing cutting-edge information and communication technologies.

Need to be mentioned for example, that improvements in solar energy use involve such novel domains as concentrating solar power technologies or printable organic solar cells. Over the past 10–15 years, microbial fuel cells for example have emerged as a versatile renewable energy technology Microbial fuel cells have the potential to generate power from organic waste materials, while simultaneously treating wastewater (Santoro, 2017). Blockchain for data security (Lv, 2021); artificial intelligence (AI) (Jin, 2020); 5G (Curwen, 2021) and transactive energy (Wu, 2021) are the technology trigger for phase where some proof-of-concept stories and media interest leads to popularization. The modern computer, IC technologies also contribute to the effective development of energy systems, for example, as an emerging power equipment status monitoring and virtual simulation technology, digital twin (DT) integrates the Internet of Things (IoT), artificial intelligence and other advanced technology (Wang, 2021) and big data (Jiang, 2016) can be applied to different life cycle of electrical equipment industrial applications (Liu, 2021). At the same time, DT can also build a parameterized virtual model of physical objects or physical processes to simulate the ultimate working state of power equipment and obtain its ultimate parameters (Khalyasmaa, 2020). DT is well suited to improve the operational reliability of renewable energy systems and reduce operation and maintenance costs. The (Wu, 2018) discusses the roles and opportunities that ICTs play in pursuing the SDGs. Mentioned paper is to discover the correlations among SDGs and information and communications technologies (ICTs). While innovation in education is not synonymous with the introduction of digital technology, innovation strategies should include the smart implementation and use of technology in a way that leverages their potential for better teaching and learning practices (OECD, 2016). The objective of mentioned paper is to discover the correlations among study process and information and communications technologies

(ICTs). The paper discusses on the conceptual level the roles and opportunities that ICTs play in the public sector in general, and in education in particular, and how these could be a major driver for significant welfare gains. The (UNIDO report- Accelerating clean energy through Industry 4.0, 2017) also stresses the interdisciplinarity (interconnectedness) as a major factor in manufacturing the next industrial revolution.

In short, the scientific literature portrays energy informatics as a field that includes topics such as smart (power) grids, renewable systems, smart meters, demand response, smart buildings, electric mobility, energy storage, data centres, energy policy, energy markets and market mechanisms (Springer: Aims and scope of Energy Informatics Journal, 2020). The (Reinhardt, 2019) defines Energy informatics as an interdisciplinary research field that encompasses all aspects of smart grids that can be addressed through the application of Information and Communication Technology, thus R&D it exclusively in the sphere of industrial applications. The (Bordin, C, 2021) aims at discussing and illustrating the main features of an introductory energy informatics course, as well as potential variants that can lead to further more advanced/specialized energy informatics courses. This will be done in light of ongoing industry trends, forthcoming education needs, and the actual meaning of the energy informatics domain. The practical aspect of benefits of energo informatics implementation in study programs are out of frame of mentioned work and it also do not discuss the use of innovation in energy and computer technologies in scope of university infrastructure development. So the need for highly interdisciplinary approach in development of educational models in accordance with industry innovations at universities of science and technology with energy informatics as a trigger element is in great demand. The role of energo informatics in strengthening of study process practical component and university infrastructure advancement will be valuable.

Above mentioned may be estimated as a trigger for productive collaboration between study process and novel principles of energy use for infrastructure support and development. Basically, energy informatics utilizes digital technology and information management theory and practice to facilitate the innovation in energy systems development generating the novel principles for awareness of energy transformation and use. This awareness will be transformed into knowledge during the study process and will be realised in form of learning at university. The innovative essence of energo informatics in theoretical and practical spheres will open not only new horizonts in educational process, but also provide a new technological solutions implementation in university applied basis.

The objective of this paper is to outline the original approach to the connection of the study process at university in the field of applied knowledge and skills in scope of energy informatics with use of novel principles of energy use for infrastructure support and development. The use of innovation in energy and computer technologies for university infrastructure may guarantee the construction of very effective base for practical training providing and R&D activities for students. This prospective interdisciplinary approach of energy informatics is addressing both to the educational opportunities and to related challenges in research and industrial innovations in higher education. The structure of this approach is summarized in (Fig. 2). University, energo informatics and innovations lay the foundation of the approach and represent the core of Fig. 2. Key elements of academic study process are on the left; practics and training- key elements of practical part- are on the right; stakeholders, industry and society represent the socio-educational, technical, and economic nature of discussed interdisciplinary approach.

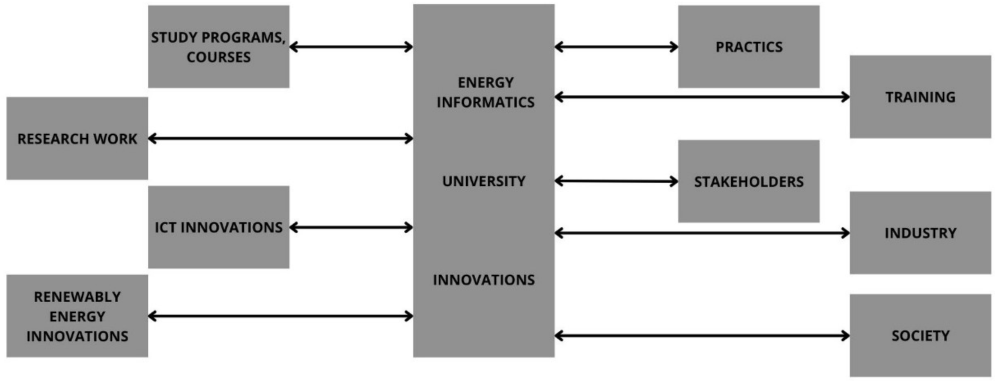

Fig. 2. Interdisciplinary approach at university
Source: composed by author.

The mission of contemporary university of science and technology is to prepare highly qualified specialists for modern and quickly developing industries. The employers in these spheres are the first to introduce new technologies into their everyday operations, which, in its turn, requires appropriate specialists with academic and professional education ready to perform their work independently, they also require specific rights to fulfil their functions immediately after graduation and be responsible for the results from the legal point of view. This means, that the specialists need approved qualifications, confirming their professional skills. Successful practical training which is a part of the study program gives a possibility for the students to receive a qualification. It is an additional competitive advantage for graduates. We are sure that as the time passes employers will increase their demand for those specialists which in addition to the professional study program will have high level practical skills. Indeed, it is necessary to develop partnerships with structures and leading experts in various fields of production, science and technology and representatives of the business community to promote the development of education in new fields of science and technology. This partnership can be carried out in various forms – participation in the development of new curricula and academic subjects, providing consultations, giving lectures and conducting practical classes, providing students with the opportunity to undergo internships at enterprises, participation in commissions for the defense of the theses. Such cooperation will allow students to achieve a higher level of practical knowledge, active cooperation will be more successful in preparing graduates who are able to immediately begin performing duties in the workplace after graduation. This becomes important at present time, when the labor market does not sufficiently satisfy all the economic, technical and legal needs for the sustainable development of applied sciences and industry. Energy informatics, which is an interdisciplinary collaboration that integrates knowledge and technology in several areas of modern technology, requires a creative model of the relationship between learning and innovation. This interaction should be carried out in optimal proportion, there will be both academic education, research and practical training. In this regard, it may be useful to establish a Steering committee included representatives from the university community and experts from the scientific and industrial community to ensure that educational plans meet the current and future needs of industry. On the other hand, the Steering committee should examine the rigor and relevance of the educational model for undergraduate and graduate programs in energy informatics.

To realize the emerging potencial of smart building technology, the symbiosis of smart building features, both as platform for education training and useful means for energy provision would be assessed as a part of new type of interdisciplinary technology in scope of energy and education. Buildings will play a critical role not only in energy efficiency, but also in a wider changing energy grid system. One of the ICT roles is being an instrument in achieving more efficient use of energy through simulation, modelling, analysis; monitoring and visualisation tools that are needed to facilitate a "whole building approach" to both design and operate buildings (Council WE, 2018). Energy informatics can facilitate a convergence of advancements in computer science applied to real-world power and energy system issues while also considering societal aspects (Bordin, 2021). In terms of residential application, TrendForce cross-examination of upcoming developments in the energy and communication sectors provides some insight into what technologies may push the residential/commercial sector forward in 2019 and beyond (Trend Force Top10 Trends for 2019, 2018). The main focus may be on ICT, and there is still a substantial crossover with energy sectors that shape the future use of technologies like commercial 5G, smartphones, memories, mini LED, eSIM, advanced sensors, EMS, etc. and their trends in the home for the years ahead in both energy generation and energy consumption (Ashley, 2019).

To conclude, the Gartner Hype Cycle (www.gardner.com, 2019) narrowed the most promising research areas down to the broad fields of artificial intelligence, blockchain, 5G, and transactive energy (Panetta, 2017). At the same time, the Gartner Hype Cycle narrowed the main industrial successful applications down to the broad fields of connected home, smart cities, and IoT in oil and gas. Also, there is a peak of industrial interest in the subjects of deep learning, energy water nexus, IoT platforms and blockchain. This key information can represent a starting point when it comes to defining part of the content of an introductory energy informatics course (Bordin, 2021).

Methods and objectives

In the framework of this article, we discuss the appropriate systemic solutions for assigned objectives. The results of article objectives must be sound and realistically achievable. The article is innovative in its essence and extends the modern approach to the industry innovations use in university study process. For example, the (Bordin, 2021) reflect the problems of research in this R&D direction, but with a comparatively narrow focus. Declared objectives: to draw an overview of the novel domain of energy informatics by addressing the educational opportunities as well as related challenges in light of current trends and the future direction of research and industrial innovation. As a result of R&D activities, presented scope of view is locally oriented without assessment of practical part of education and analysis of positive innovation impact on university infrastructure. A higher education innovation system can be seen as a set of functions, components and relationships, which allow us to disaggregate the various levels of interactions among the elements of the system and analyse the unfolding of innovation in higher education by (Brennan, 2014) is concentrated mostly on structural and relational connections between the parts of innovation system. In the next article, there are illustrated and discussed some of the challenges for modelling method, that allows the planning, implementation, and dissemination of educational innovation. This work presents the different steps that make up the method above: the used methodology, the included duties, the needed effort, the technological background, and its impact prediction (Fidalgo-Blanco, 2018). Offered article allow adequate allocation of innovation implementation in learning process, practical trainings, development of versatile university infrastructure and study process management efforts, and it is essential to point out the knowledge gaps in our current understanding of the impact of innovations at university. Now, the more traditional concept of university as R&D center for innovations generation in industry is prevailing. The exposed in article conception does not challenge this position, but strengthen it by means of more comprehensive innovation implementation at university and consequently, the generation of more effective feedback to industry.

The described activities have general and specific objectives. The overall objective of the article is to ensure and maximise the innovative nature of study process and sustainability of university R&D and energo informatical infrastructure to assess the necessary changes in study process, to outline the means of infrastructure development and encourage the production, management and to share the knowledge in sphere of energetics and ICT. The specific objectives are:

- Interdisciplinary approach assessment based on energo informatics promotion in scope of study process, research providing new knowledge in harmonization of the existing and additional study programs and courses in structure of studying; the best practices for the management of the mentioned promotion, better understanding of the problem and increase of the knowledge resilience.

- Exposition and evaluation of practical training and R&D activities provision for students learning on the engineer study programs and support of innovative research infrastructure to address the challenges related to energetics and ICT.

- Assessment of novel techniques and methods for the implementation and sharing of industrial experience and innovations in environmental and infrastructural potential of university.

The foundations will be laid for a future development of interdisciplinary approaches in study processes in applied science universities. The concept of smart environment on premises of the university will be introduced. The diagram illustrated the main elements of systematic composition of complex system incorporated energo informatics as interdisciplinary element of study process, smart educational environment as base for practical training, R&D activities, IBEMS-innovative infrastructure of university and ICT system for campus is demonstrated in (Fig.3).

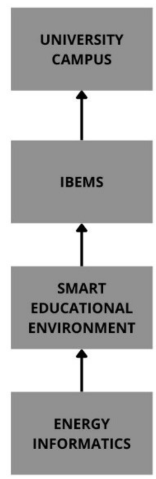

Fig. 3. Energy informatics in the structure of smart environment on premises of the university
Source: composed by author.

Results

The chosen approach for conducting research activities implements critical analysis of a concept, using the printed and electronic sources data and hybrid descriptive method. Types of research data: secondary, observation and derived. As the basic point, we do not accept the paradigm of analysing only content of a single energy informatics course rather than complete energy informatics study programmes (Bordin, 2021). The maturity of energo informatic and strengthening of background for implementation of industry innovations in study process from STEM approach with appeal to need to bring together work across disciplines to investigate which change theories are used and how they inform change efforts (Reinholz, 2021) mandate us to discuss the broader path to implement energo informatics at the level of Bachelor, Master and Doctoral programs. At the beginning of study of typical for applied sciences university study programs suitability for energo informatics implementation we discuss the models, including description of the Study Program, indicators describing the Study Program and mapping of the study courses/ modules for the achievement of the learning outcomes of the study program, compliance of the interdisciplinary study program with the provision of the Law on Institutions of Higher Education.

The typical model of Bachelor study program in sphere of energo informatics.

Title of the higher education study field: Power Industry, Electrical engineering, and ICT.

Study Program name: Energo informatics.

Type of the study program: Professional bachelor study program.

Goal of the study program: The aim of the study programme is to provide professional Bachelor education in computerised control of power electrical technologies, corresponding to the 5th professional qualification level (electrical engineer), and to prepare students for professional Master studies in different subfields of power electrical engineering, which would allow them to pursue a Doctoral degree.

Tasks of the study programme: To provide knowledge in mathematics and physics for solving practical electrical and electronic engineering problems; to learn how to use computer and information technology skilfully and efficiently both for solving problems and for developing automation and control systems; to learn to solve practical power electrical engineering problems at project level; to give an understanding of the design, basic operation, automation and robotics of power electrical and electronic equipment; AI elements in complex systems; to learn how to solve power electrical and electronic automation and robotisation problems, AI elements use at project level; to give an understanding of the energo informatics application aspects; to give an idea and knowledge of work organisation, social issues and economic principles; to strengthen foreign language skills.

Results of the study program: Graduates of the study programme: are able to apply theoretical knowledge in mathematics and physics to solve practical power electrotechnical and IT problems; are able to use computer technology effectively for solving energo electrical engineering problems and for developing automation and robotic systems; are able to solve practical technological problems at project level; are able to demonstrate an understanding of the design, operating principles, automation fundamentals and robotics, IT use of power electrical equipment; are able to solve automation and robotisation tasks at project level in power electrical engineering; are able to demonstrate an understanding of the electrogenic aspects; are able to demonstrate an understanding of the planning and organisation of work, social and economic principles; are able to acquire professional literature in a foreign language. Graduates of the study program obtain a Professional Bachelor Degree in Power Electrical Engineering, which allows them to continue their studies at the professional Master level, as well as receive a Qualification of Power Electrical Engineer.

Final examination upon the completion of the study program: The Qualification paper - Bachelor Thesis.

Study programme form: Full time studies - 4 years. Duration in full years 4. Amount (ECP) 240.

The program is implemented in the field of Power electrical engineering, but with an in-depth study of information technology for application in computer-aided automation of electrical equipment. During the studies, a minimum of 5 months of internship is undertaken, as well as study projects are developed within 3 important study courses of the programme, thus enabling students to acquire practical design skills. The volume of the professional Bachelor study programme is 240 ECP. It consists of study courses (189 ECP), internship (33 CP) and a state examination (18 ECP).

Professional Bachelor study program content and structure.

General education study courses (30 ECP), as example, Introduction to Specialty (1.5 ECP); Theoretical basic courses related to the appropriate field (60 ECP), as example, Power electrical engineering (4.5 ECP); Professional specialization courses related to the appropriate field (90), as example, Electrotechnological Equipment (7.5 ECP); Elective courses (9), as example, Effective Lighting (3.5 ECP). The main idea of content and structure composition is to provide for students possibility to acquire knowledge from the beginning learning content of General education study courses, then to master content from Theoretical basic courses in the field, then- from Professional specialization courses with support from elective courses. The theoretical knowledge in cooperation with laboratory works, practical trainings, internship ensures skills and practical experience. Program mapping provide logical and sustainable development of study process from first to last semester during the period of program realization.

The typical model of Master study program in sphere of energo informatics.

Title of the higher education study field: Power Industry, Electrical engineering, and ICT.

Type of the study program: Professional Master study program.

Goal of the study programme: Training of a new generation of graduates in the fields of electric power networks systems and grids, recording and monitoring of their operation modes, as well as stability and reliability, by actively implementing smart technologies including ICT and AI technologies, namely: Optimal control technologies, applicable to the energy market, as well as to generation, transmission, distribution, consumption, and energy saving; Expertise in energy demand and saving, techniques for efficient use of energy in construction, manufacturing, the primary sector, and transport; Development and integration of various control systems and energy efficiency models in scope of energo informatics development.

The main task is to train qualified specialists for successfully solving today and future problems in Power industry field: Monitoring and control of operation modes for all the participants of the energy generation, transmission, and consumption process (producers, traders, large and small consumers);

Quick reaction to changes in various parameters of the power system and reliable power supply in transmission and distribution networks, with a large share of produced wind, solar and other types of sustainable energy; achieving effective and modern decentralized control of a “distributed” power system; Educational and disseminative work among passive consumers (small consumers of renewable energy resources), converting them into active participants of the demand response process, as prosumers, to ensure effective implementation of the gains in R&D.

Results of the study program: The study program is planning to provide the students with in-depth knowledge in power and electric engineering, smart systems, ITC technologies during lectures, practical classes, laboratory work and internship, and to ensure skills in the fundamentals of scientific research work as well as to develop research skills and train highly qualified specialists in the field of smart power systems in field of energo informatics (including the specializations in power supply, control of distributed electric power networks and systems and electric machinery and apparatus) and to prepare the students for further doctoral studies. Graduates of the study program obtain a Professional Master Degree in Power Electrical Engineering, which allows them to continue their studies at the professional Master level, as well as receive a Qualification of Leading Power Electrical Engineer.

Final examination upon the completion of the study program: Master’s thesis.

Study programme form: Full time studies – 1.5 years. Amount (ECP) 90.

The program is implemented in the field of Power electrical engineering, but with an in-depth study of information technology for application in computer-aided automation of electrical equipment. the Master degree program is developed for the graduates of the Bachelor program in order to obtain scientific research and management skills in the sphere of energo informatics. During the studies, a minimum of 1.5 months of internship is undertaken thus enabling students to acquire practical design and management skills. The volume of the professional Master study program is 90 ECP. It consists of study courses (51 ECP), internship (9 CP) and a state examination (30 ECP).

Professional Master study program content and structure.

Courses that ensure the acquisition of the latest achievements (21 ECP), as example, Information technologies in modern energy systems (3 ECP), Ecology of tenergy systems (3 ECP); Research and design work and management courses (30 ECP), as example, International project management (3 ECP), Human factor and risk management in energo systems (4.5 ECP). The concept of content and structure composition reflects the necessity to give to the students in-depth knowledge in power and electric engineering, smart systems, ITC technologies in accordance with development of scientific research and management skills in sphere of energo informatics. The future graduate and specialist will get the ability of self realization both in scientific sphere and as skillfull manager at the enterprise. Program mapping has a mission to provide sustainable development of study process with more scientific research, project design, modern management oriented bias during the period of program realization.

The typical model of Doctoral study program in sphere of energo informatics.

Title of the higher education study field: Power Industry, Electrical engineering and ICT.

Type of the study program: Doctoral study program.

Goal of the study programme The aim of Doctoral studies is to train high-qualified specialists in the area of computerised control of Power energy objects, who can solve tasks of scientific novelty, and to prepare lecturers for high schools and researchers for scientific institutions, the experts for scientific community bodies.

Tasks of the study program: to provide knowledge to PhD students about tasks and methods of research for complex computer controlled Power energy technical objects and systems; to provide knowledge to PhD students about methods of technical innovations and R&D; to provide to PhD students knowledge and skills for pedagogical work; to strengthen the knowledge of foreign languages to the level necessary for international scientific discourse, to provide skills in presentation of scientific results; to promote skills in international project management and implementation of internationally important research and dissemination of research results.

Results of the study program: PhD studies result in the obtaining of knowledge for further scientific, managerial and pedagogical work, which in terms of competences and skills can be characterized as follows: able to apply theoretical knowledge for the solution of scientific problems; able to organize and implement pedagogical activities; able to design and develop innovative systems of computer control for electrotechnical and power equipment used in different branches of economy; able to design and develop innovative electronic devices, semiconductor devices of a power converter, electric propulsion systems and robotic equipment; able to conduct internationally significant research, implement dissemination of research results through international publications and conferences; able to apply knowledge of foreign language at the level of international scientific discourse.

Final examination upon the completion of the study programme PhD Thesis (dissertation).

Study type and form: Full time studies – 4. years. Amount (ECP) 288.

The volume of the Doctoral study program is 288 ECP. It consists of study courses (63 ECP) and a state examination (225 ECP).

Degree to be acquired: Doctor of Science (Ph.D.) in Power electrical engineering, Electronics, ICT. During PhD studies, an individual cooperation with the scientific adviser is provided to the PhD students for mastering compulsory, field-specific and free elective study courses on aspects of application of principles of computer control of Power electrical technologies in different branches of economy with bias to energo informatics. In the second phase of the study process, only scientific studies are carried out on an individual subject related to computer control of electrical technologies and this phase is completed with the development and defence of dissertation and obtaining PhD degree. The aim of the study programme is to educate and train highly qualified specialists and researchers in the fields of power energetics, electrical engineering, electrophysics, computer control of electrical technologies, electrical propulsion, power electronics, robotics and motion control, capable of generating new knowledge, developing new electrical and electronic equipment and their control methods, and being able to experimentally test and introduce them for valorisation. The second aim to be mentioned is the training of the young scientist for universities and scientific research institutions. The main tasks are to provide PhD students with knowledge of research, development, modelling, experimental simulation, testing and valorisation of new electrotechnical equipment and technologies; to develop skills in pedagogical activities; to strengthen knowledge of a specialised technical foreign language at international level; to develop skills in management and implementation of international projects and to disseminate results of their research on local and international level.

Professional Doctoral study program content and structure.

Compulsory Study Courses (22.5 ECP), as example, Intelligent Electronic Equipment (6 ECP), Optimization of Parameters of Power Electronics Converters (9 ECP) ; Compulsory Elective Study Courses, Field-Specific Study Courses (31.5 ECP), as example, Automation of Electrical Technologies (9 ECP), Expert Systems of Industrial Electronics (15 ECP); Free Elective Study Courses (9 ECP) and a state examination (225 ECP).

The concept of content and structure composition reflects the necessity to give to the students in-depth knowledge in power and electric engineering, smart systems, ITC technologies in accordance with development of scientific research and management skills in sphere of energo informatics. The future graduate and specialist will get the ability of self realization both in scientific sphere as researchers at scientific organizations and as skillfull managers at the enterprise, as instructors / lecturers at higher education organizations, specialists in engineering of high qualification. Program mapping has a mission to sustainable development of study process with more scientific research, project design, modern management and pedagogical activities oriented bias during the period of program realization.

The main research areas of this study programme are: Power electronic converters and their control systems; Development of control systems with artificial neural networks and fuzzy logic controllers; New electric propulsion systems and motion control; Development of expert systems in electrotechnological processes; Development and research of alternative energy conversion systems; Multi-criteria analysis of logistic decisions for energy systems; Use of power electronics and electric propulsion systems in electric vehicles; Research on electromagnetic compatibility of power electronic converters; Development and research of supercapacitor energy storage systems; Power tool propulsion manufacturing technologies and their optimisation, etc. This means that a broad level introduction of the two areas of energy and informatics should be given within the programs with particular regard, for example to: energy and power systems fundamental concepts such as energy network, smart grids, micro grids, climate change, energy policy, energy economics, market mechanisms, smart buildings, future energy systems and low carbon systems.

To provide this broad variety of topics and ensure the introduction of novel courses in the study process dictates also the implementation of new teaching technologies, for example- e-learning. Educational organizations have made changes in their teaching programmes for the students to be able to get better education and show higher success. The most salient one in these changes is e-learning in which information access and transfer is easy. Emerged as an alternative to formal education, e-learning is more functional as an assistance to existing teaching systems. The points missed in traditional classroom environments can be taught and reinforced thanks to e-learning. Vivid imagining of abstract concepts can be easier by means of simulation programmes, the system profit. Besides, visual objects and simulations are also key factors to a permanent learning. Moreover, one thing we have gained from the COVID-19 pandemic - improved skills in providing distance lectures using digital tools. It is confirmed in (Ivanova, 2020), that e-learning is fast progressing scientific field, proposing novel and specific approaches in a range of domains. It is a well established practice in universities, schools and organizations for delivering interactive, adaptive and flexible training, taking advantage of contemporary and emerging technologies. Informatics is a continually evolving science, presenting its theoretical and practical advances applicable in various research areas, including in eLearning. So this assumption also refers to energy informatics. It can be said that a new direction of research e-learning, focused on mutually connected topics in the scientific fields, has to be explored and the best practices to be studied and analyzed. It will be extremely beneficial to researchers, academicians, learners, as well as to experts and professionals that are responsible for implementation and deployment of technological solutions in organizations.

To ensure the interrelated ties of innovations in industry with university the practical part of the study process will be implemented in a modern infrastructural environment with an up-to-date building management system with embedded sensors, climate control systems, energy-efficient lighting, etc., which also serves as a means of research. In parallel different laboratories will be provided for the students, for example: Power Electronics and ICT Training Laboratory; Electrical Propulsion Training and Research Laboratory; Manufacturing Automation Training and Research Laboratory; Computer Management Training and Research Laboratory; Microelectronics and Sensor Training and Research Laboratory; Energy Efficiency Training and Research Laboratory; Electronic Equipment Training Laboratory; Electrical Engineering Fundamentals Laboratory; Electrical Engineering and Electronics Training Laboratory; Research Laboratory of Robotics and Mechatronics. Applied Informatics Laboratory. The modern specialized microprocessor systems for components and systems design and simulation in control processes for example on Arduino uno base are provided . Advanced software for digital simulation and research: CAD, CAM, CAE, MATLAB, Multisim are provided for project realization in enerco informatics field.

The concept of Smart educational environment will be realized. For example, modular platform described in (Simic, 2016) may be used for practical use in the sphere of energy informatics, which provides student services in smart educational environment. The platform represents a point of mutual integration of various services, such as hosting platform for students' projects, platform for integrating SMS service with students' web applications, Internet of Things platform which enables acquiring data from sensors distributed within the university campus and controlling various actuators and sensors. Platform is deployed as a part of Smart Learning environment. It is suitable for student practical training and control and management as useful part of an integrated building energy management system (iBEMS) (Fig. 4). The infrastructure and technical support available for the implementation of the study programs, thanks to a high level of digitization, provide an opportunity to increase the competitiveness, quality, and efficiency of the university, as well as the availability of information, by integrating information technology (IT) solutions into the university's administrative, study and research work processes, providing students, administrative and academic staff with modern, reliable, secure and integrated IT infrastructure and high quality IT services.

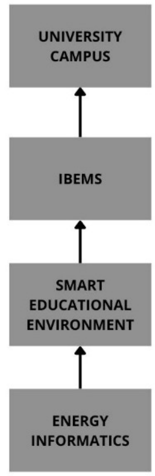

Fig. 4. Energy informatics in the structure of university and its campus iBEMS
Source: composed by author.

Conclusions

The obtained results would make a novel contribution to the outlined outcomes specified in this article and to the wider impacts in the longer term. Offered concept is in compliance with response to the (United Nations: Sustainable Development Goals, 2015), while at the same time ensuring the security and safety of energy supply (European Union 2050) Long term strategy (2019) by means of industry innovations use in study process at university. Interdisciplinarity in form of energo informatics as provider of industry innovations use was validated. The principle of application of modern energy and IC technologies to ensure the sustainability of the university infrastructure was justified. The article will directly and significantly contribute to specific scientific advances, across and within disciplines (not only to energo informatics development, but also in a broad sense, to novel interdisciplinary models of education creation and knowledge generation. Reinforcement of scientific equipment and instruments, and computing systems (i.e., research infrastructures).

Among the main obtained results of realised in frame of presented article activities we would like to expose the main of them:

1. Justification of interdisciplinary approach on example of energo informatics as trigger for industry innovations implementation and use in study process at university was presented. The justification has been provided in form of critical analysis of a concept using the literature as data. The results of state of art evaluation in the field give the positive proof of viability of proposed hypothesis.

2. The new concept of massive parallel energo informatics implementation in form of multilayeral set of study programs

was formulated. Validation of concept (hypotesis) has been accomplished in form of descriptive model combined 3 study programs at different levels of competence for the students. The detailed description, definition of goals, tasks, results, structure and composition has been provided.

3. The playsible hypotesis of complex model combined study process, smart educational environment for the students, a new direction of research e-learning, focused on mutually connected topics and university infrastructure improvement was drown up. The integrated model was presented and analysed.

4. Exposition and evaluation of practical training and R&D activities provision for students learning on the engineer study programs and support of innovative research infrastructure to address the challenges related to energetics and ICT has been provided.

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INTERDISCIPLINARY ASPECTS OF INDUSTRY INNOVATIONS USE IN STUDY PROCESS AT UNIVERSITY

Vladimirs Reiskarts

Summary

The paper provides a brief analysis and exposes the need for more intensive use of ICT in combination with modern sources and methods of renewable energy for efficient implementation of modern control and management technologies. The objective of this paper is to outline the original approach to the connection of the study process at university in the field of applied knowledge and skills in scope of energy informatics with use of novel principles of energy use for infrastructure support and development. Justification of the role of interdisciplinarity in form of energo informatics as provider of industry innovations use in study process at university is one of the tasks on the path to objective.

The concept of interdisciplinary has been expanded not only in the field of interaction between different disciplines in the scientific field, in the field of education, but also in the field of application of modern energy and IC technologies to ensure the sustainability of the university infrastructure. Critical analysis of a concept using the literature as data and hybrid discriptive method were implemented for assigned tasks realization. Concept of interdisciplinary approach at university in scope of innovative essence of energo informatics in theorethical and practical spheres will open not only new horizons in educational process, but also provide a new technological solutions implementation in university study environment . Among the main obtained results of realised in frame of presented article activities we would like to expose the main of them: 1. Justification of interdisciplinary approach on example of energo informatics as trigger for industry innovations implementation and use in study process at university was presented. The justification has been provided in form of critical analysis of a concept using the literature as data. The results of state of art evaluation in the field give the positive proof of viability of proposed hypothesis. 2. The new concept of massive parallel energo informatics implementation in form of multilayeral set of study programs was formulated. Validation of concept (hypotesis) has been accomplished in form of descriptive model combined 3 study programs at different levels of competence for the students. The detailed description, definition of goals, tasks, results, structure and composition has been provided. 3. The playsible hypotesis of complex model combined study process, smart educational environment for the students, a new direction of research e-learning , focused on mutually connected topics and university infrastructure inprovement was drown up. The integrated model was presented and analysed. 4. Exposition and evaluation of practical training and R&D activities provision for students learning on the engineer study programs and support of innovative research infrastructure to adress the challenges related to energetics and ICT has been provided.

The article will directly and significantly contribute to specific scientific advances, across and within disciplines (not only to energo informatics development, but also in a broad sense, to novel interdisciplinary models of education creation and knowledge generation, reinforcement of scientific equipment and instruments and computing systems (i.e., research infrastructures).

In our opinion, an interdisciplinary association of various disciplines, methodological approaches, such as energy and computer science, in the process of qualified specialists education, provision of technical base for the implementation of practical training and the use of renewable energy sources for the provision of the university campus sustainability is promising for implementation of industry innovations in study process at university.

Key words: Energy informatics, University, Interdisciplinarity, Smart infrastructure.