

# Metrology, Electrical Energy Markets and Engineering Education at University of Novi Sad (Serbia)

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**Abstract** – This paper begins with presentation of the main facts about University of Novi Sad (Serbia) and its Faculty of Technical Sciences. Important results of metrology in electrical engineering from past to nowadays, at Faculty of Technical Sciences (University of Novi Sad), are consequently described. The role of the Centre of Metrology is recognized as the basis for cooperation between university and industry in the field of metrology. All these parameters enabled ELEMEND – EU ERASMUS+ project for electrical energy markets and engineering education which is being implemented at University of Novi Sad. Finally, this resulted with developing modernized education curricula: studying program "Measurement-information Technology and Control Engineering" and studying module "Measurement-Information Systems".

**Keywords:** metrology, markets, engineering education, Serbia, electrical energy

## 1. INTRODUCTION

The University of Novi Sad (Serbia) is one of the largest scientific and educational centres in Central Europe with more than 50,000 students and 5,000 employees. It belongs to the so-called complete or comprehensive universities, which are characteristic of covering almost all areas of science and higher education.

Within the University, almost 400 accredited study programs are realized at the level of basic, master, specialist and doctoral studies, whose holders are faculties and university centres for interdisciplinary and multidisciplinary studies. Study programs are contemporary and follow the development of science. Three scientific institutes also play an important role in creating a scientific basis for their permanent modernization, apart from faculties and centres.

Faculty of Technical Sciences in Novi Sad is a higher education and scientific research institution whose mission is the realization of high quality educational processes, development of scientific disciplines and transfer of acquired knowledge in economy and society. Since its inception in 1960, the Faculty of Technical Sciences is dedicated to the realization of its mission based on the

successful results of scientific research work and their application in practice. Over time, the Faculty has, according to the established needs of the economic environment, as well as the current needs of the society, developed study programs that educate students for existing and emerging technical-technological and socio-economic systems, developing at the same time their own, competent human and natural resources.

The Faculty of Technical Sciences realizes its mission in three interrelated basic groups of activities: higher education, scientific research work and knowledge transfer in the economy. In doing so, it constantly improves the educational programs, the quality of the work process and human and material resources, with the tendency to reach the highest standards. In this way, the Faculty of Technical Sciences ensures the satisfaction of the educational needs of young generations, the scientifically professional needs of the economy and the material needs of the employees, and as part of a wider educational and scientific system, represents the driving force of the development of the society.

The vision of the Faculty of Technical Sciences is that, as an equal partner in a simple European area of higher education in scientific research, it achieves the highest levels of excellence, or a high position in the company of the best. On the Road to Meeting Your Vision, the Faculty expands its competency and work framework to partnering with universities and business organizations from all over the world, adopting positive trends in the global education and research system.

The orientation towards modern study programs and quality studies creates conditions for faster growth and development with the real understanding of the need for education in a characteristic environment. A large number of international scientific projects and a comprehensive transfer of obtained results in the economy of the building adds value and competence of the participants in the education process, all in order to achieve the set vision.

At the Faculty of Technical Sciences, there is the Department of Power, Electronics and Communication, which is consisted of 6 chairs, including Chair of Electrical Measurements. The Faculty of Technical Sciences also

established Centre of Metrology and Laboratory of Metrology. This 3 entities (Chair of Electrical Measurements, Centre of Metrology and Laboratory of Metrology) are the main points of education, science and industrial development of Metrology in Electrical Engineering at University of Novi Sad.

## **2. IMPORTANT RESULTS OF METROLOGY IN ELECTRICAL ENGINEERING FROM PAST TO NOWADAYS**

One of the main metrological results in the 1960s in Serbia is a current comparator. One of the three authors is the late academician Petar Miljanic [1]. This current comparator enabled for 2 lines of measurement the measurement of large AC and DC current. The current comparator was created as a result of the cooperation between Electrical Engineering Institute Nikola Tesla (Belgrade, Serbia) and National Research Council (Ottawa, Canada), which is still ongoing.

The second major metrological result is the MSB001 wattmeter, the longest time being the world's best travelling standard of AC electric power [2]. The authors are P. Miljanić, B. Stojanović and P. Bošnjaković [2]. The wattmeter was created in Institute Mihailo Pupin in the mid-1980s.

The third major metrological result is the automatic calibrator of the electric power of author I. Zupunski, based on stable digital generation of the AC voltage and AC current signal and the voltage and transconductance amplifier and MSB001 in the feedback [3].

The fourth significant result is the AC power calibrator of accuracy and stability of 10 ppm, by Z. Mitrovic [4].

Regarding industrial measurements, one of the largest results is the electronic counter of P. Miljanic, B. Stojanovic from the 1990s. "Professional electronics Ei-Niš" produced it in a series of about 500,000 copies.

The high-accuracy industrial measurements were performed by the monophasic VMP-20 power analyzer, serially produced in 1996 at the Faculty of Technical Sciences, University of Novi Sad. The authors are V. Vujičić, S. Milovančev, D. Pejić [5]. Due to the simple handling and simple man-machine interface, it is still used today.

For the purposes of efficient monitoring of electricity consumption and detection of theft, in 2011 the MM4 was installed for Public Company "Elektroprivreda Srbije". MM4 is the quadruple three-phase power analyzer. The device was designed at the Chair of Electrical Measurements of the Faculty of Technical Sciences, University of Novi Sad, and it was produced by the company "Nigol" from Petrovaradin. It has been operational since 2013.

Nowadays, Electrical Engineering Institute Nikola Tesla is the most important regional (and even broader) producer of high-end electrical and power standards. As part of the University of Belgrade and national institutions, he has the knowledge and intellectual property of applying the mentioned current comparator and is a worthy continuator and guardian of the tradition in this field. The developed

calibrator, is being applied in the region of Southeast Europe and the Balkans.

In 2017, at the Faculty of Technical Sciences (University of Novi Sad), the digital high-performance low-level detector was constructed on new principles by B. Vujičić and I. Župunski [6]. The Chair of Electrical Measurement, the Centre of Metrology and the Laboratory of Metrology of the Faculty of Technical Sciences (University of Novi Sad) are currently developing several methods for its efficient use.

In 2017, a proven method of measuring active power of very high accuracy [7] has been published, which enables the realization of the watt meters of the standard accuracy.

In 2018 a proven method of measuring electrical power and energy was published according to the standard "IEEE Std. 1459. 2010." [8].

Based on the paper [8] and its key result, a stochastic digital DFT processor (SDDFT), it turned out that the problem defined in [8] - real-time finding of the most significant higher current and voltage harmonic in the low voltage network or microgrid - can be effectively solved. This is very important for managing real-time flows of electrical power and energy in the low voltage network, that is, the microgrid. It may be even more important in the protection. This is the immediate forthcoming task facing the Chair, the Centre and the Laboratory.

## **3. CENTRE OF METROLOGY AS THE BASIS FOR COOPERATION BETWEEN UNIVERSITY AND INDUSTRY**

The Centre of Metrology as the centre of technical and technological infrastructure is being formed in order to provide assistance to companies in the region in achieving better positioning on the market.

Assistance in the application of standards in several areas, training in the application of standards, the introduction of technical and technological infrastructure into the company's business for the purpose of applying standards and certification of products and services are the imperatives.

Having in mind that the backlog in all these areas is very large compared to the situation in the countries of the region, and that awareness of the need for introducing standards into business is still present only in a small number of companies that have made the market enforce standards, there is a need to improve the situation through a system approach by forming a Centre that will in one place consolidate information about companies (enterprises), key people in those companies, products and services in the territory covered by the Centre for its activities.

In this way, all interested in one place will find all the information they are interested in the area covered by the Centre, as well as the necessary advice and training on the certification of their products and services. With this kind of established database, the Centre also becomes the source of key analytical information and reports and for the management structures in the region.

The main goal of the Centre is to provide a neutral and competent organization for satisfying information and consulting services in the areas of standardization,

metrology and intellectual property, as well as in the field of conformity assessment (certification) accredited by the Accreditation Body of Serbia, or authorized by the competent state authorities, for the certification of certain products, that is, systems and services.

In accordance with the stated main goal, in managing the processes at the Centre, which should ensure satisfaction of the defined Mission, Vision and / or Policy of the Centre, are the following objectives:

- Providing satisfactory resources, primarily in terms of personnel, equipment, business or work space; methods and procedures, as well as appropriate financial means;
- Merge system knowledge, modern technology and user needs in designing and implementing services, in order to provide relevant and quality services to users, in line with current regulations or standards;
- Expanding the user's circle and creating strong cooperation with them;
- Selection of organizations and individuals - associates of the Centre, in accordance with their ability to meet the requirements of the Centre and the requirements of its users;
- Realizing a business relationship with partners, in terms of strict compliance with commitments and fair respect for their own and partner's interests;
- Focused development in the areas for which there is an expressed interest, basic resources and realistic expected, acceptable results;
- Systematically arranged and systematically documented work process and workflow;
- Improving the work process and the appropriate methods and procedures, or the development of the Centre in accordance with real needs and secured resources;
- Providing the conditions for permanent education, motivated and responsible work of the staff.

As a regional body, the Centre will, as a regional body, efficiently and effectively perform tasks in the mentioned areas, with reasonable price and short deadlines, which is extremely important for proving the competence of the economy, achieving a defined and reproducible product quality and achieving not only competitive prices and other effects, but in general placement of products on domestic, and especially European and world markets.

The operation of the Centre implies providing adequate financial results, as compensation for the services provided. However, the Centre will not aim to achieve high profits, but only the means to cover its own functioning and directional development.

By integrating and using existing human, technical and other resources, with a small complement to these resources, the Centre will ensure the rational use of these resources and visible effects for economic, scientific and other organizations, as well as for individuals and the community as a whole.

#### **4. ELEMEND – EU ERASMUS+ PROJECT FOR ELECTRICAL ENERGY MARKETS AND ENGINEERING EDUCATION**

Intelligent grids and microgrids are recognized as a world changing trend that will reshape all energy related industry and business. The emergence of microgrids has been facilitated by the developments in renewable energy sources RES and distributed generation technologies as well as ICT technologies allowing telemonitoring, telemetering and intelligent control of the grid.

These developments follow suit the liberalization of the electricity markets in EU which break away from the traditional state-owned vertically integrated monopoly controlling generation, transmission and distribution of electricity. These new paradigms of electricity grids and markets require that the staff operating in the new technological and economical environment, as well as electricity end users, are properly educated and trained. Smart grids are part of the EU 2020 strategy, that promotes smart, sustainable and inclusive growth.

The EU has a goal to replace at least 80% of electricity meters with smart meters by 2020 at the places where it is cost-effective to do so. HEIs in EU countries are expediting curriculum changes and implementing new programmes in order to educate and train the engineering students and retrain professionals in smart grids topics. The electrical engineering curricula in Western Balkan countries, established to support the classical model of one large scale power grid, owned and operated by one company, need to be modified.

Even though RES and ICT technologies are part of the WB curricula, they are examined as separate technologies and not as part of a new type of grid, the smart (micro) grid. Nor are they studied under the light of the new electricity market structure these emerging technologies dictate. The engineering students receive a good education in power engineering and ICT but they are not trained to use, analyse and implement these technologies as components of integrated systems which need to be themselves integrated into bigger grids exchanging data in real time with remote control and operation.

Moreover, they are not educated to evaluate the performance of such systems taking into account market considerations which place the end user in a decision making position. Modernization of curricula to address smart microgrids and electricity markets is ultimately important for the security of the infrastructure as well as the improvement of the daily lives of ordinary citizens in WB countries involved in the project.

WB countries have placed Engineering and engineering education in their regional priorities with respect to: a) learning and teaching tools and methods which are served by ELEMEND proposing the introduction of and training in innovative teaching methods such as e-, gamified and blended learning b) university-enterprise cooperation and employability of graduates which is a key element in ELEMEND implementation of the internship programme currently not in place in WB countries and the university –

enterprise ELEMEND network supported by the participating industrial partners.

National priorities of Bosnia & Herzegovina and Montenegro are covered by the regional priorities as outlined above as well as the emphasis on quality assurance processes. The national priorities of Serbia do not include Engineering and Engineering trades but a) interdisciplinary areas which the ELEMEND project serves by definition tackling ICT, power engineering and markets and b) the development of R&I capacities which ELEMEND serves through the training and teaching in smart grid/microgrid technologies and electricity markets.

ELEMEND addresses the need for capacity building in engineering teaching staff and MSc students through: 1. the modernization of existing BSc engineering curricula at partner country HEIs by introducing new courses or reshaping existing courses in BSc level (6 courses in WBC HEIs) 2. the introduction of new Master programmes (120 ECTS / 60 ECTS) in Smart grids at WBC universities involved in the project 3. the Introduction of ICT based teaching methods - the development of gamified content and course content for e-learning platforms that will be used in the teaching process 4. the training and retraining of teaching staff in all partner country HEIs ELEMEND addresses the upgrading of the teaching infrastructure placing emphasis on laboratory and project work. Simulation laboratory and smart grid laboratory will also be implemented.

ELEMEND promotes the university - enterprise cooperation through the active involvement of companies in the project in the shaping of the course material and content. Industrial partners have a strong commitment and interest in the outcomes of the project and look forward to its graduates. The cooperation will be fostered through the 30 days student internships in local companies in the field of smart grids. So, the project is directly addressed to the academic staff at the Engineering faculties (Electrical or IT), BSc and MSc students and SME employers in the sector of Electrical engineering but is also inherently interdisciplinary since the study of electricity markets is an indispensable component.

The pooling of resources via the ELEMEND project will facilitate the introduction of intelligent microgrid technologies in the consortium HEI's and will act as a multiplier of the existing advantages in the region of Western Balkans namely, the relatively small geographic distance, common language, common culture, common history and compatible education systems.

University of Novi Sad emphasizes the role of metrology in ELEMEND project, through expertise provided by Centre of Metrology and Chair of Electrical Measurement.

## 5. EDUCATION CURRICULA OVERVIEW

Education in measurement technology and electrical engineering covers a wide range of complex topics. In order to have these topics appropriately adopted by students, it is necessary to have appropriate representative examples in teaching themes. These examples deal with the synthesis of key segments in the fields of measurement-information systems and algorithms; metrology; realization of precise measurements; sensors and measuring converters; intelligent

measurements in sensory networks; biomedical engineering - biomedical instruments, devices and systems; engineering technologies in the concept of Smart Health; engineering technologies in cognitive neurosciences; measurements in electricity; measuring and information technologies in the concept of Smart Grid; measurements in electronics; engineering technologies in the concept of Smart Home; engineering technologies in the concept of Smart Building; engineering technologies in the concept of Smart City; measurements in the concept of Smart Agriculture; measurements in the industrial environment; engineering technologies in the concept of Industry 4.0; measuring information technology in the Internet of Things (IoT) environment; measuring and information technologies in environmental protection; measurements in telecommunication systems; measuring and information technologies in automotive systems.

On the basis of previous experiences from the study program "Measurement and Control Engineering" and the study module "Measuring Systems" (within the study program "Power, Electronics and Telecommunications"), at Faculty of Technical Sciences, University of Novi Sad, as well as on the basis of harmonization of this program and module with ERASMUS + project ELEMEND, this program and module have been developed under the harmonized new names "Measurement-information Technology and Control Engineering" and "Measurement-Information Systems".

## 6. CONCLUSION

The Faculty of Technical Sciences from University of Novi Sad (Serbia) has developed many scientific and education departments and appropriate studying programs. Metrology in electrical engineering has been developed at the Faculty of Technical Sciences through 3 main entities: Chair of Electrical Measurement, Centre of Metrology and Laboratory of Metrology. EU Erasmus+ project ELEMEND enabled developing modernized education curricula: studying program "Measurement-information Technology and Control Engineering" and studying module "Measurement-Information Systems".

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