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DEPARTMENT OF ENERGY AND POWER SYSTEMS – 80 YEARS OF SUCCESS IN SCIENCE, TEACHING AND COOPERATION WITH INDUSTRY

SUMMARY

The Department of Energy and Power Systems of the Faculty of Electrical Engineering and Computing, University of Zagreb was founded in 1934 and celebrated its 80th anniversary in 2014. In its long history, many well-known experts, members of the Department, have left their mark on the power engineering activity in Croatia. The Department has been studying and creating improvements in the fields of production, transmission, distribution and final use of electricity, renewable energy sources, advanced power grids, electricity management problems, electricity trading and markets problems and usage of other forms of energy.

Throughout the years, the Department has become the leading institution in the field of electrical power engineering in the region, maintaining long-term cooperation with the industry sector and has been recognized for scientific activity since the time of professor Požar and his establishment principles of the Zagreb School of Energy. Determined to remain a respectable research institution, the Department undertakes scientific research at the highest international levels through which valuable international cooperation with many research institutions around the world has been established.

Key words: Department of Energy and Power Systems; Electrical engineering; Energy; Power systems; Faculty; Anniversary; Curriculum

1. INTRODUCTION

The Department of Energy and Power Systems studies and brings improvements in the fields of generation, transmission, distribution and the use of electrical energy, energy efficiency, high voltage engineering, renewable energy sources, smart grids, problems of power systems management, nuclear engineering and safety, electricity markets etc.. The Department has been the leading institution in the field of electrical power engineering in the region, with the long lasting cooperation with the utilities and industry, and has been recognized for its scientific activities and a large number of published scientific papers in globally relevant journals, as well as numerous national and international scientific projects. In parallel, during the years the Department continued its development with a commitment to the permanent improvement of its curriculum.

This article describes the history of the Department of Energy and Power Systems, its current infrastructure and plans for the future. It mentions the most important people contributing to the development of the Department, describes the curriculum modifications and provides insights into the less known historic facts from the 80 years long Department history. At the end, the paper shows the ongoing project of the transition of the existing Power systems laboratory to a modern Smart Grids Laboratory (SGLab) serving within a Bologna Declaration compliant curriculum.


2. HISTORY OF THE DEPARTMENT

2.1. The Department establishment and High-Voltage Current study profile.

The Technical College in Zagreb was founded by the decree of the State Commissioners' Council on 10th of December 1918 and welcomed its first students on 1st of October 1919. It was one of the first technical high education schools in the South-east Europe. Among other departments, the College had the Department of Electrical Engineering. On 31st of March 1926 the Technical College was transformed into a faculty, joined with University of Zagreb and renamed to College of Engineering [1]. Already in academic year 1921/22. the first power engineering subjects appeared when honorary teachers Ing. **Edgar Montina** lectured the subject “Decree of the Electrical Centers and the Network”, and in the academic year 1926/27. Ing **Miroslav Plohl** lectured the subject “Transmission and Distribution of Electricity and High-Voltage Techniques”. It is interesting to mention that from the beginning of the studies until the early 60s, under the influence of the German study methodology, the study programme was divided into two basic profiles: the High-Voltage Current profile and the Low-Voltage Current profile.

Professor **Juro Horvat**, associate professor at the University of Ljubljana, who came to the College of Engineering in Zagreb in the summer semester of year 1932/33., was employed as the first permanent lecturer in the field of power

engineering as a full professor. When Juro Horvat joined the College of Engineering, the course “Power Engineering” was introduced, followed by “Electric Energy Production” in the academic year 1933/1934 and by “Transient Processes in Electrical Devices” in the academic year 1935/1936. After the tragic death of Professor Miroslav Plohl in late 1939, **Anton Dolenc** took over the duty of part-time lecturer in the subjects of High-Voltage Techniques.

	<p>Juro Horvat, dipl. ing, was born on 17th of April 1882 in Gospić, where he finished elementary school. He finished high school in Vinkovci in 1900 and electromechanical engineering graduate studies at the Graz Technical High School in 1904. After graduating, he worked in factories around Stuttgart, Geneva and eventually as director of the company "Energos" in Vienna. He worked on the first Slovenian HPP "Fala" on Drava river. From 1924 he was a lecturer at the Faculty of Engineering in Ljubljana and from 1932 at the Faculty of Engineering in Zagreb. He was the founder of the High voltage department in 1934. He in parallel dealt with problems of electrification and published papers in the respected journals of that time such as <i>Electrotechnik und Maschinenbau</i>. He was one of the founders of the Banovinski Electrical Engineering Company in 1937 in Zagreb. He retired in 1947 and passed away in Zagreb on 18th April 1954.</p>
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The arrival of prof. Horvat fulfilled the preconditions for establishment of The Department of Energy and Power Systems, which was established by the Faculty council of the Technical College on its 129th regular session held on June 26th, 1934. Under item 13 of the agenda (Figure 1) the proposal of prof. ing. Jure Horvat to establish a Laboratory for High voltage engineering was accepted, which today's Department of Energy and Power Systems originates from. As a Head of the Chair of Electricity Generation, Transmission and Distribution prof. Horvat founded the Department to enable laboratory work for the students, as well as to enable scientific research and professional work of the staff. He was the first Head of the Department (Table I). Through his work, some of the instruments and equipment were acquired, together with technical magazines and books, which were the foundation for the establishment of the Department's laboratories and libraries.

Table I Department's Heads

	Head of the Department	Mandate	
1.	Prof. ing. Juro Horvat	1934.-1943.	<ul style="list-style-type: none"> • Since its establishment, the Department has been led by 14 Department Heads • The founder of the Department and its first Head was prof. ing. Juro Horvat. • The longest mandate as a Head of the Department belongs to prof. dr. sc. Božidar Stefanini who led the Department for 24 years. In ac. year 1958/59. at the same time he served as the Faculty Dean and as the Head of the Department • In ac. year 2002/03 the function of Head's assistant was introduced. Four lecturers have been performing this function so far.
2.	Prof. ing. Vladimir Žepić	1948.-1952.	
3.	Prof. dr. sc. Božidar Stefanini	1952.-1976.	
4.	Academician dr. sc. Hrvoje Požar	1976.-1978.	
5.	Prof. dr. sc. Mario Padelin	1978.-1982.	
6.	Doc. Željko Zlatar	1982.-1986.	
7.	Prof. dr. sc. Danilo Feretić	1986.-1990.	
8.	Prof. dr. sc. Vladimir Mikuličić	1990.-1994.	
9.	Prof. dr. sc. Vjekoslav Filipović	1994.-1998.	
10.	Prof. dr. sc. Zdravko Hebel	1998.-2002.	Head's assistant
11.	Prof. dr. sc. Slavko Krajcar	2002.-2006.	Prof. dr. sc. Nenad Debrecin
12.	Prof. dr. sc. Nenad Debrecin	2006.-2010.	Prof. dr. sc. Tomislav Tomiša
13.	Prof. dr. sc. Tomislav Tomiša	2010.-2014.	Prof. dr. sc. Igor Kuzle
14.	Prof. dr. sc. Igor Kuzle	2014.- today	Prof. dr. sc. Davor Grgić

P O Z I V

na 129 redovnu sjednicu Savjeta Tehničkog fakulteta Univerziteta
Kraljevine Jugoslavije u Zagrebu za utorak dne 26 juna 1934 u 16 sati.

Dnevni red:

- 1/ Čitanje zapisnika 128 redovne sjednice.
- 2/ Izvještaj dekana.
- 3/ Izvještaji starješina.
- 4/ Izbor dekana za 1934/35 školsku godinu.
- 5/ Predlog prof. dra Njegovana i dra ing. Hanamana da se univ. docent dr ing. Krajčinović Matija postavi za vanrednog profesora za katedru za Organsku kemijsku tehnologiju / II čitanje/.
- 6/ Predlog prof. ing. Plohla i ing. Horvat Jure da se univ. docent Dr Lončar Josip postavi za vanrednog profesora za katedru za Osnove elektro tehnike i električna mjerenja /Teorijsku elektrotehniku i električna mjerenja/ /II čitanje/.
- 7/ Predlog prof. dra Njegovana i dra Plotnikova da se dr. ing. Prelog Vladimir postavi za univerzitetskog docenta za katedru za Organske hemiju. /II čitanje/.
- 8/ Predlog Arhitektonsko-inženjerskog otdjeka da se predavanja iz Uredjenja gradova /Urbanizma/ 2 i 2 u zimskom semestru i 2 i 4 u ljetnom semestru povjere arh. Hribar Stjepanu kao honorarnom nastavniku uz propisani honorar po održanom času /II čitanje/.
- 9/ Predlog Gradjevno-inženjerskog otdjeka da se predavanja iz Arhitekture za gradjevinare 2 i 0 u zimskom i 2 i 2 u ljetnom semestru povjere ing. Denzler Juraju kao honorarnom nastavniku uz propisani honorar po održanom času /II čitanje/.
- 10/ Predlog prof. dr ing. Hanamana i prof. ing. Stipetića da se vanredni profesor ing. Sahazarov Artemij izabere i postavi za redovnog profesora na katedri za Mehaničku tehnologiju /I čitanje/.
- 11/ Predlog Arhitektonsko-inž. otdjeka i Gradjevno-inž. otdjeka da se raspise Stečaj za popunjenje jednog mjesta vanrednog profesora na katedri za Statiku konstrukcija.
- 12/ Predlog prof. ing. Plohla da se osnuje Laboratorij za slabu struju.
- 13/ Predlog prof. ing. Horvat Jure da se osnuje Laboratorij za visoki napon.
- 14/ Izvještaj Kuratorija, izbor članova Kuratorija zaklada Dra Jurja Žerjavića i za unutarnje uređenje.
- 15/ Izbor pretstavnika Tehničkog fakulteta u Odbor Univerzitetske biblioteke.
- 16/ Kventuslija.

U Zagrebu, dne 23 juna 1934.

Prodekan:

Dr. Njegovan, v. r.



Figure 1. Agenda of the 129th regular session of the Technical College on which the Department foundations were set

The beginning of the 2nd World War marks the beginning of the stagnation of Department activities. Prof. Horvat travels abroad, for which he was unwillingly retired later in 1943. After the end of the War, he returned to Zagreb, attempted to re-activate at the Faculty, but did not succeed and finally retired at the beginning of 1947.

After the 2nd World War the Department was consequently left with only two honorary lecturers: **Mladen Dokmanić**, dipl. ing., from academic year 1945/46, and **Fedor Jelušić**, dipl.ing. from academic year 1946/47. Everything had to be reinitiated from the start at a time when large number of students entered University and when the need for engineers was rapidly increasing in the developing country.

In academic year 1948/49 as a permanent teacher in the position of the associate professor **Vladimir Žepić**, dipl. ing. was selected. Vladimir Žepić later also becomes the Head of the Department.

Vladimir Žepić was born in 1894 in Zagreb, and before being admitted to the Department, he worked as an engineer at the municipal power station and was a prominent member of Rotary Club Zagreb. In 1945 he became the first technical manager of the Electrical Company of Croatia (ELPOH). He became the member of the Department in 1948. He was forced from the Faculty as a politically unsuited by the government at the end of the winter semester 1951/52. He died in 1971.

At the end of the 1940s new members come to the Department, members that will later be the bearers of development and will bring the Department international recognition. At the beginning of the summer semester 1949/50 the position of assistant professor in the Department was trusted to **Božidar Stefanini**, dipl. ing., and in academic year 1950/51. **Hrvoje Požar**, dipl. ing. was elected as the assistant and honorary professor. After the forced departure of prof. Žepić from the Faculty, Head of the Department at the beginning of ac. year



Božidar Stefanini, PhD was born in Split on October 18, 1913. He graduated in 1937 at the Technical College of Zagreb. Until 1950 he worked on high voltage network implementation in Yugoslavia's power utility company and then moved to the Technical Faculty of Zagreb where he obtained his PhD in 1954. He was elected full professor in 1959 at the Faculty of Electrical Engineering. He was the head of the High-Voltage Department (from 1952 to 1976) and Dean of Faculty in 1958/59. He is one of the founders of the University Computing Center (SRCE) and the most prominent person for procurement, installation and implementation of IBM1130, first Computing System at the Faculty of Electrical Engineering. He taught the courses of Electric Power Transmission, High Voltage Engineering and Power System Stability. He wrote the first books on Fortran IV programming language and co-authored book "Matrix methods in power system network analysis" (1975). He received "Nikola Tesla" award for scientific work in 1972. He died in Zagreb in March 1991.

1952/53 becomes Božidar Stefanini.

Since the beginning of the 1950's, the Departments intensive development has begun, which was enabled by more available laboratory space. The Department was first located in one, and later in two rooms at Rooswelt Square no. 6. In 1950 it moved to the first floor of the building in Vukotinovićevea Street no. 2, where it got

enough space for laboratories, from which the most important is the High-voltage laboratory established in 1954. The great credit for that goes to **Boris Markovčić**, dipl. ing. As the laboratory was established practicum for students was introduced in a form of 6 experimental exercises. In 1953, a photo-laboratory for slides production was installed at the Department, which were used for lectures. The study of High-voltage currents was nine- semester long and elective courses were introduced with the purpose of more focused student specialization.

As part of the study of High-Voltage Currents in the academic year 1950/51 two study profiles were established: Electro-industrial profile and Electric Power profile. The Department for High Voltage becomes the bearer of teachings in the



Hrvoje Požar, PhD was born in Knin on July 5, 1916. He graduated in 1939 at the Technical Faculty of Zagreb. He started his career as power systems designer and dispatcher (1946-51) and then moved to Electrical department on the Technical Faculty (that later became Faculty of Electrical Engineering) where he obtained his PhD in 1955. He was elected full professor in 1960 and performed duty of a Dean in 1960/1962 and 1968/1970. He was the head of Department for High Voltage and Energy and the founder of the Zagreb Energy School. He was Yugoslavian Academy of Science and Arts associate member from 1965, full member from 1975 and secretary-General from 1978. From 1970 to 1972 he was the Vice-Rector of the University of Zagreb. Since 1976 he was Editor-in-Chief for Technical Encyclopedia (volumes V-XII). He also worked at the Institute for Electric Power from which today's Energy Institute "Hrvoje Požar" originates. He was a member of Croatian Constitutional Commission in 1990. He received numerous awards and acknowledgments. He received "Nikola Tesla" award for scientific work in 1963.

Electric Power profile (Appendix I).

Special attention was also given to the professional work, which was carried out with extensive cooperation with the economy and industry sectors. At that time, scientific work was done not only by individual members of the Department but also by the Department as a whole with the extensive usage of expanding laboratory equipment and libraries. At that time **Branko Jermić**, long-term director of the TEŽ factory, joins the Department as a honorary professor of the subject "Electric Lighting".

2.2. 1956: Faculty of Electrical Engineering (ETF)

By the decision of the Parliament of the People's Republic of Croatia, on 26th of April 1956, the former College of Engineering of the University of Zagreb was divided into four new faculties, one of them becoming the Faculty of Electrical Engineering, which started its independent existence on 1st of July 1956.

This was the start of the third, modern stage in the development of electrical engineering in Croatia, characterized by a turbulent development in electronics, electrical power engineering, automation, communication technology and computing. First independent curriculum (ETF-1) started its application from academic year 1959/60 in which profiles of High-voltage currents and Low-voltage currents are still present. The most significant change is reduction of direct lectures

student engagement from 40 hours/week (according to curriculum from 1950/51) to 30 hours/week. The average student engagement of 30 hours/week has not changed till today which serves as a confirmation of forethought of professors of that time who managed to recognize the right amount of weekly student obligations already 60 years ago.

In order to respond to fundamental goals of academic education and social requirements Faculty changed its curriculum seven times from its beginnings. The 8th change of curriculum is now planned for academic year 2018/19 (FER-3). All curriculums with according subjects of the Power engineering profile are listed in the appendix section (Appendix I).

After the gain of independency of the Faculty the working conditions for the Department improved significantly, especially after the transfer to the 6th floor of the newly built Faculty building “C”. The Faculty buildings "A", "B" and "C" at the present location (Unska 3, Zagreb) were completed and equipped by the year 1965 (building “A” in 1961, building “C” in 1963. and building “B” in 1965) and were fully operational.

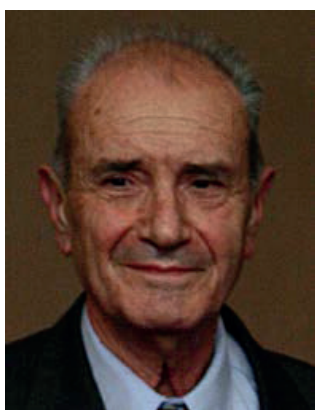
In that time (after 1965.) the Department equipped, alongside already mentioned high-voltage laboratory, power facilities laboratory, electric lighting laboratory and relay protection laboratory. The high-voltage laboratory and power facilities laboratory were been located in adequately large facilities in the newly built building “B” (High-voltage laboratory on 300 m² and Power facilities laboratory on 200 m²). Furthermore, available space in the Department premises was used for establishment of well-equipped Department library. Library contained more than 2000 books and was monthly receiving more than 40 different technical journals and magazines. Furthermore, at that time the Department already utilizes digital computers for solving problems in power engineering. Therefore, the installation of IBM 1130 computer in the University computing center had an even further positive impact both on the computer aided teaching and professional and scientific activities. The biggest contribution in that regard goes to prof. Božidar Stefanini and prof. Hrvoje Požar who were both constantly improving the curriculum with the latest international scientific achievements.

Postgraduate studies (Master of Science (Mr. sc.) degree) started from the academic year 1964/65. In the initial part of High-current postgraduate studies Department had lectures: “Machine operation”, “Frequency and voltage control”, “Power system scheduling”, “Power system construction”, “High voltage network construction and design”, “Power network analysis”, “Relay protection”, “Transmission stability”, “Overhead lines”, “Power network overvoltage”, “High voltage impulse testing”, “Hydro power plant operation” and “Thermal power plant operation”.

In academic year 1967/68 Faculty introduced new curriculum (ETF-2) with three-way studies: Power engineering, Electronics and Electrical machines and automation. Study duration was four years with initial two years the same for all the students. Courses were divided in lectures and exercises. New curriculum reduced lectures from professors from Faculty of mechanical engineering and naval architecture and increased number of lectures in the field of electrical engineering.

New courses held by the Department include: “Overvoltage protection” and “Relay protection”. “Electrical grids and installations” course changed the name to “Electric power distribution”. There were also various new elective courses established and taught by Department members. New department professors were **Marko Padelin**, **Milan Šodan** and **Željko Zlatar**.

After only three years of application of ETF-2 the new curriculum change followed in academic year 1970/71 (ETF-3). Power engineering became one of the 3 study profiles. There was an increase in number of required courses held by Department. New courses were: “Energy fundamentals” and “Electric power systems” while the course “Electric power transmission” was divided into “Electrical power lines” and “High voltage networks” courses. “Low voltage grids and installations” became required course of the study profile and “Nuclear power engineering” became the new elective course. With other three elective courses on nuclear power engineering they were the foundation of future Nuclear Power Engineering sub-profile. Number of elective courses in the field of electric power networks also increased. Basic (required) courses were lectured by aforementioned professors and by new professors: **Vjekoslav Filipović**, **Srđan Babić**, **Mirjana Urbiha-Feuerbach** and **Vjekoslav Srb** (honorary professor) who were all representative of the new generation of Department members. ETF-3 separated laboratory and auditorium exercises and introduced practical student projects.



Danilo Feretić, PhD was born in Omišalj on October 13, 1930. He graduated in 1954 at the Technical Faculty of Zagreb. He finished postgraduate studies in England and received his PhD in 1967. at the Faculty of Electrical Engineering in Belgrade. He worked at the Power Engineering Institute in Zagreb, 1954-55, Institute for Nuclear Science "Boris Kidrič" in Vinča 1959-63, Energoinvest in Sarajevo 1963-67, Institute for Nuclear Research in Egypt 1967-74, in Zagreb Electric Power Utility 1974 -82. He was the Technical director of Krško nuclear power plant under construction. In 1968 he worked at the Faculty of Mechanical Engineering and Naval Architecture in Zagreb, where he became a full professor in 1979. In the same year he moved to the Faculty of Electrical Engineering (now Faculty of Electrical Engineering and Computing) where he served as a Dean for the 1992-1994 mandate and became Professor emeritus in 2002. He is engaged in nuclear power and the influence of nuclear power plants on the environment and power plant construction and design. He worked as an expert for the International Atomic Energy Agency. He has published several books and won many awards, some of which are: "Nikola Tesla" (1991), "Fran Bošnjaković" (1997), "Ruder Bošković" (1998), and the State Lifetime Achievement Award (2007).

2.3. 1978: Department of Power Systems (ZVNE)

In 1978, the department changed its name from High-voltage Department to the Department of Energy and Power Systems (in Croatian: *Zavod za visoki napon i energetiku*). The research work at the Department was significantly improved with the acquisition of an electronic computer in 1980. The computer was regularly used in three shifts according to its usage schedule.

In ac. year 1978/79. a new ETF-4 curriculum was introduced, where Power Engineering became one out of eight study profiles. It is important to emphasize that Nuclear Power Engineering profile was introduced to the Faculty's curriculum for the purpose of education of engineers in nuclear energy field, as the NPP Krško was under the construction. Professor **Danilo Feretić** was highly creditable for the development of this profile. In the Power Engineering profile a new course "Energy Processes" was introduced. Power engineering study profile on the fourth year was branched into three specialization programs:

- Power System Construction and Operation
- Power System Management and Control
- General Electric Power Engineering

Profile Power System Construction and Operation varies the least from the previous ETF-3 curriculum. In profile Power System Management and Control several new courses from the field of regulation, automatization and digital electronics were introduced: "Regulation in Electric Power System", "Control in Electric Power System" and "Digital Control". General Power Engineering profile introduced subjects which studied matter that is not only related to electricity issues but also to all forms of energy: "Energy Sources", "Energy Systems and Balance", "Economy in Energy". Nuclear Power Engineering profile was transformed into Energy Technology profile in ac. year 1990/91.

During the 80s, the Department developed with the increase in the number of young teachers who took over the courses: **Zdravko Hebel, Vladimir Tuk, Vladimir Mikuličić, Sejid Tešnjak, Slavko Krajcar, Nikola Čavlina** and **Ivo Uglešić**. The development is particularly reflected in more extensive professional and scientific work, cooperation with the industry sector and international professional and scientific cooperation. International exchanges and visits of expert, especially with regard to the expansion of activities in the field of nuclear energy further increase the relevance of the Department. All these activities also resulted in a considerable increase in the number of staff members, most of whom have achieved scientific their titles in the Department.

With the support of the industry and government new building (building "D") was built and inaugurated in 1989 where Department of Energy and Power moved in and stayed up to today. Building construction was led by ex-Dean and Department employee Professor Milan Šodan. During year 1991 significant number of modern software packages for electric power system analysis and measurement equipment have been acquired, which significantly improved Department scientific work capabilities and enabled introduction of modern teaching techniques. Since then, every member of the Department had a computer, and thanks to that, more diversified collaboration with the economy was established. This led to further acquisition of new and modern computers, which contributed to further advancements in the work of the Department. The Department library of that time had more than 5,000 books and was receiving over 50 different journals.

During the Croatian War of Independence (1991-1995) there were difficulties in performing the work and teaching, primarily due to frequent danger alarms. Despite the hardship, during this period a new curriculum was formed which

received the name FER-1 after (1995) the Faculty changed its name to Faculty of Electrical Engineering and Computing.

2.4. 1995: Faculty of Electrical Engineering and Computing (FER)

The Faculty of Electrical Engineering (ETF - *Elektrotehnički fakultet*, in Croatian) existed under this name until 7 March 1995 when it was renamed to Faculty of Electrical Engineering and Computing (FER - *Fakultet elektrotehnike i računarstva*, in Croatian). Faculty was renamed to follow the global trends characterized by the rapid development in the field of computing.

The first generation of students enrolled FER-1 curriculum in the academic year 1994-95. The general characteristic of this curriculum is a significantly higher choice of courses (in the study profile Power Engineering students had to engage 40 hours of courses instead of the previous 13 hours of elective courses). A certain number of elective subjects were from other study profiles. In the organizational sense, the following changes have been made - instead of the previous profiles Power Engineering and Energy Technologies, which were chaired by the Department of Energy and Power Systems, a unique study of Power Engineering with two profiles was introduced: profile Energy Systems and profile Energy Technologies, while the ETF-4 curriculum profiles mentioned before was abolished.

The Department staff was significantly expanded by employing new associates: **Ante Marušić, Tomislav Tomiša, Davor Škrlec, Nenad Debrecin and Ivica Pavić.**

The Department continued its development with a commitment to the permanent improvement of its curriculum. Soon, the curriculum was changed again (to be named FER-2) due to the Bologna declaration. The Bologna Declaration was signed by 29 European countries in 1999, adopting the new three-step university education system: bachelor, master, and doctoral studies. Today, the Bologna Process is implemented in national qualification frameworks of 47 European countries, including Croatia. At the Faculty of Electrical Engineering and Computing (FER), University of Zagreb, this involves a 3-year bachelor program, followed by a 2-year master program and a 3-year doctoral program. The master program at FER covers three fields: Electrical Engineering and Information Technologies, Information and Communication Technologies, and Computer Science. Each field was divided to profiles, and Power Systems was a study profile within the Electrical Engineering and Information Technologies field [8].

Since the individualization of the classes that students attend is one of the main objectives of the Bologna reform, each profile consisted of five mandatory courses, one laboratory course, and a minimum of 13 elective courses (Appendix I). Additional motivation for introducing this laboratory-only course is to increase the importance of laboratory exercises in master studies. When laboratory exercises were just a part of theoretical courses, the students were mostly focused on the theory-based exams since these accrued most points towards the overall grade. The low amount of points students could accumulate at laboratory exercises marginalized their significance.

Introduction of the laboratory-only course rectified this shortcoming of the previous master program FER-1 and recognized three shortcomings of today's engineering education: a need for more general engineering technical knowledge, a need for more hands-on experience, and a need for higher level of professional awareness.

The main goal of laboratory focused teaching is to enable students to apply and test theoretical knowledge they mastered in previous years of studies. The laboratory courses enable them to develop practical skills in various fields of power engineering in a controlled environment. Furthermore, students are provided with the possibility of performing experiments and tests that would otherwise be either too expensive or nearly impossible to carry out in a real power system.

The Department, within the curriculum FER-2, introduced a number of new subjects for the study profile of Electrical Power Engineering. Furthermore, transversal subjects serving the educational needs of the whole Faculty were also introduced and included: "Sustainable Development and Environment", "Economics and Managerial Decision Making" (in joint organization with ZOEM), "Management in Engineering" (in joint organization with ZOEM and ZTEL) and "Risk Management". For all students of Electrical Engineering and Information Technology there is also the subject "Energy Technology" being taught on the second year of bachelor study.

3. THE DEPARTMENT TODAY

After the year 2000 the Department staff number continued to grow with **Zdenko Šimić, Željko Tomšić, Davor Grgić, Igor Kuzle, Marko Delimar, Viktor Milardić and Juraj Havelka**, being accepted as young teachers. All of these teachers, responsible not only for teaching, contributed to professional and scientific development of the Department by means of improved cooperation with the industry sector and improved international academic cooperation. The Department facilities were continually upgraded with equipment and software acquired from funds earned by industry cooperation projects or from domestic and international scientific projects. These projects enabled further staff growth by employing doctoral students, postgraduate students and expert associates who all together represented Department's future potential.

Today, the Department has five research laboratories that include:

- Smart Grid Laboratory (SGLab)
- Laboratory for Energy and Environmental Markets and Exchanges (LEEMaE)
- Power System Protection Laboratory (PSP Lab)
- Atmospheric Phenomena Laboratory (APPLY)
- Laboratory for Nuclear Energy and Safety (LNES)

whose Heads are : **Igor Kuzle** (SGLab), **Željko Tomšić** (LEEMaE), **Juraj Havelka** (PSP Lab), **Ivo Uglešić** (APPLY) and **Nikola Čavlina** (LNES).

Today, the Department is the leading national and regional research and higher education institution, with excellent teachers and students, closely linked with the industry sector, excellently organized and internationally recognized.

Our mission is:

- to educate students capable of carrying out the technological and social development of Croatia through education and research in the fields of electrical power engineering and energy systems, using scientific background from applied mathematics and applied physics;
- to create new knowledge by internationally acknowledged research and by development of safe, clean and efficient energy sources;
- to innovatively develop the economy and public services, hence contributing to the overall development of the society;
- to be an institution of high academic values and ethical principles, a site of critical thinking and questioning, and of equality for all its members;
- to be the driving force of the power sector in the Croatia.

The Department staff was also involved in the organization of important international conferences, of which most significant were:

- International Conference on the Nuclear Option in Countries with Small and Medium Electricity Grids which so far had 10 editions, biannually, located each time in different Croatian city
- International Conference on Power Systems Transients (IPST 2015), Dubrovnik, Croatia, 15-18 June 2015
- IEEE International Energy Conference (IEEE ENERGYCON 2014), Dubrovnik, Croatia, 13-16 May 2014
- EUROCON 2013 - The International Conference on "Computer as a tool" (IEEE EuroCon 2013), Zagreb, Croatia, 1-4 July 2013
- 8th International Conference on the European Energy Market (EEM11), Zagreb, Croatia, 25-27 May 2011

The Department is also the holder of a specialist postgraduate study of Railway Electrical Engineering Systems (study head **Ivo Uglešić**) which is being carried out since 2012. The underlying reason for launching a specialist study program is to improve the development, design, production and maintenance of railway electrical systems components, which requires application of modern methods and interdisciplinary knowledge.

Regarding the teaching curriculum development, the Department has always has a rich history and has always followed world trends in the development of power engineering and related sectors that are of the scientific interest to the Department. The curriculum development continues today with the preparation of the eighth curriculum change, for which introduction is planned by the academic year 2018/19.

A large number of employees of the Department are actively involved in the shaping of a newly-introduced dislocated undergraduate program of the University of Zagreb titled "Energy Efficiency and Renewable Energy study program" located in Šibenik, which is planned to start in the academic year 2015/16.

4. DISTINGUISHED MEMBERS OF THE DEPARTMENT

Several Department members made a significant contribution to the development of the academic community in Croatia. The position of the Dean of Faculty of Electrical Engineering was held by five professors (figure 2) from the Department for High Voltage and Energy, and several of them had additional significant functions at University of Zagreb level (Table II).



Figure 12. Distinguished members of the department serving as Deans of the Faculty

Apart from the university duties, certain staff members of the Department were engaged in socio-political activities, especially professor **Željko Tomšić**, who served as Assistant Minister for Energy and Mining in the period 2004-2008, and professor **Davor Škrlec**, who was elected as a Croatian representative in the European Parliament on 1st of July 2014.

Some staff members have left an indelible mark in sports activities like long-time professor and former Head of the Department professor **Zdravko Hebel** who won the gold waterpolo medal at the 1968 Olympics in Mexico. In addition to the aforementioned medal, professor Hebel was also the President of the Croatian Olympic Committee in the period 2000-2002.

In the field of professional organizations activities, significant work was done by professor **Hrvoje Požar** as the President of JUGO CIGRE 1968-1972, and recently professor **Ante Marušić**, who was the Vice-president of HRO CIGRE, professor **Marko Delimar** and professor **Igor Kuzle**, who have been active in the IEEE association and serving prominent positions: Marko Delimar as the Director of IEEE Region 8 and IEEE Secretary and Igor Kuzle as Vice-President for Technical Activities in IEEE Region 8 and as the President of the Croatian Section of IEEE. Professors **Nikola Čavlin**, **Zdenko Šimić** and **Davor Grgić** were the Presidents of the Croatian Nuclear Society.

Table II. List of distinguished Department members and their functions

1.	Prof. Božidar Stefanini, PhD	<i>1956.-1957. vice-dean</i>
		<i>1958.-1959. dean</i>
		<i>1959.-1962. vice-dean</i>
		<i>1971.-1979. director of the University Computing Centre (SRCE)</i>
2.	Academic prof. Hrvoje Požar, Phd	<i>1960.-1962. dean</i>
		<i>1962.-1966. vice-dean</i>
		<i>1968.-1970. dean</i>
		<i>1970.-1972. vice-rector</i>
3.	Prof. Milan Šodan, PhD	<i>1980.-1982. vice-dean</i>
		<i>1982.-1984. dean</i>
4.	Prof. Sejid Tešnjak, PhD	<i>1988.-1990. vice-dean</i>
5.	Prof. Danilo Feretić, PhD	<i>1990.-1992. vice-dean</i>
		<i>1992.-1994. dean</i>
6.	Prof. Slavko Krajcar, PhD	<i>1990.-1996. dean assistant</i>
		<i>1996.-1998. vice-dean</i>
		<i>1998.-2002. dean</i>
7.	Prof. Vladimir Mikuličić, PhD	<i>1994.-1996. vice-dean</i>
8.	Prof. Nenad Debrecin, PhD	<i>1998.-2000. vice-dean</i>
9.	Prof. Tomislav Tomiša, PhD	<i>2002.-2006. vice-dean</i>
10.	Prof. Marko Delimar, PhD	<i>2014.- today vice-dean</i>

5. PUBLICATIONS

Department's publishing activity has been continuously improved since its establishment. Significant footprint was left by the books by prof. Hrvoje Požar which have been used by many generations of students and experts. Besides numerous university textbooks, Department members published more than 30 books (Appendix II). After Croatian War for Independence, publishing activities were slowed down but in recent years they have been on a gradual increase.

Significant improvements have been made in scientific research as more and more papers are published in prestigious international journals. Also, considerable investments obtained by international projects are channeled into improvement of the laboratories.

6. FUTURE DEVELOPMENT

Future development is based on improving laboratory capacities.

6.1. Transformation from Power system laboratory to Smart grid laboratory

Power system laboratory was neglected for many years due to its size and lack of funds needed for the refurbishment. Laboratory started with operation on 4th of January 1969 when small hydro power plant model became operational. Shortly after that small thermal power plant model was also completed. They were unified into the interconnected power system. The laboratory can provide students and researchers with valuable ability to test and apply theoretical knowledge on real machines in controlled environment. Further laboratory improvements and investments are oriented towards renewable energy sources integration following mandatory European Union guidelines for all member countries. Current power system concept based on centralized generation is moving towards Smart Grid concepts which integrate centralized and distributed generation with new control capabilities and technologies. The output of the renewable energy sources is variable and of stochastic nature, which requires changes in the current practices of the power system operation. On the other hand, growing environmental awareness and strong political impetus have promoted new technologies that help reduce the emissions (e.g. electric vehicles).

In order to provide the students with the necessary knowledge of advanced and smart grid technologies, the decision to modernize the current laboratory and transform it into Smart Grid Laboratory (SGLab) was reached. Along with the existing AC microgrid, a new DC microgrid is being developed. It will comprise of different renewable energy sources and energy storage devices, different batteries types being used to run electric vehicles, different demand-responsive loads, as well as multiple AC/DC converters and DC/AC inverters to allow interaction between the AC and DC microgrids. Therefore, the existing miniature electric power system in the Laboratory that resembles Croatian electric power system (Figure 1) will be drastically expanded to better include the transition power system is undergoing.

Addition of different renewable energy sources and DC microgrid will enable research in the field of RES integration and demand flexibility. Following activities and investments are planned for the SGLab:

- Hydro power plant reconstruction;
- Thermal power plant reconstruction;
- PV generation installation (60 various technology and installation PV modules);

- Li-ion batteries for electric vehicle simulation acquisition;
- Battery energy storage installation;
- AC/DC and DC/AC converters installation;
- AC and DC controllable loads introduction;
- Various distributed generation models connection;
- Modern power system protection completion;
- Modern SCADA system installation.



Figure 1. Miniature power system (1—thermal turbine; 2—hydro turbine; 3—transmission network).

7. CONCLUSION

During the past 80 years since the founding of the Department as a component of the College of Engineering of the University of Zagreb (1934-1956), the Faculty of Electrical Engineering (1956-1995) and the Faculty of Electrical Engineering and Computing (from 1996 until today) a wide range of great historical and scientific events have occurred connected with the Department. States and social systems have been swapped, wars have passed, economic and international relations have changed, new curricula and study programs have been introduced, organizations of the University and faculties have changed. Locations, buildings, lectures, laboratories, cabinets and people changed, but the most significant changes were in the development of new technologies and the creation of opportunities for scientific research and improvement of overall teaching at the Faculty. There were also many other less significant changes that marked the past and affected the present life of the Department. The Department, as one of the oldest institutions in the field of technical sciences at the University of Zagreb,

participated in all this in a very specific way and left many significant results that are relevant even today.

The paper presents the development of the Department since its establishment in 1934 to the present days. The Department's intensive development began in 1950 with the introduction of the new courses in accordance to the new curricula (High-voltage current study profile). Throughout the years laboratories as well as scientific and professional work were developed. This paper, in addition to the historical overview of the Department activities and the most prominent employees gives a review of the study curriculum development and changes. Furthermore, guidelines for the future development of the Department were given through the plans for improvement of practical teaching with students within a Bologna Declaration compliant curriculum as a part of a modern power system laboratory that is currently under reconstruction.

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APPENDIX I - CURRICULUMS

Study profile: High-voltage Current – Electric Power Engineering, academic year 1951/52

Third year			Fourth year		
Required courses	Semester		Required courses	Semester	
	Winter	Summer		Winter	Summer
Heat Machines	4+2	-	Heat Machines	2+1	-
Hydraulic Machines	-	3+1	Hydraulic Machines	3+1	-
Theory of El. Engineering	3+2	3+2	Electrical Machines Testing	2+4	2+4
Electrical Measurements	1+3	1+3	Electric Power Transmission	4+3	4+3
Electric Materials Technology	3+1	-	Electric Power Stations	2+2	3+2
Electrical Facilities	2+2	-	Fundamentals of El. Economy	2+0	-
El. Grids and Installations	4+4	4+3	Electrical Machines	4+4	-
Electrical Machines	3+3	3+3	Encyc. of High-frequency Tech.	-	3+0
Industrial Buildings	-	2+1	High Voltage Engineering	-	2+1
Encyc. of Wired-comm. Tech.	-	3+0	Organization of Power Utilities	-	2+1
Power Routers	-	2+0	Geodesy in Power Utilities	-	1+1
Pre-military Training	2+0	2+0	Pre-military Training	2+0	2+0
			Elective course	<i>min 6 hours</i>	
			Theory of Electrical Engineering	-	2+2
			Economics in Power System	-	2+1
			Electrical Machines	-	3+5
			Construction of El. Devices	-	3+1
			Motor Drives	-	3+1
			Power Transmission Stability	-	2+0
			Electrical Lighting	-	2+2
			Electrical Railways	-	2+1
			Electric Power Dispatch	-	2+1
			Exploitation of Water Resources	-	2+0

Study profile: High-voltage Current – ETF-1, academic year 1959/60

Third year			Fourth year		
Required courses	Semester		Required courses	Semester	
	Winter	Summer		Winter	Summer
Heat Machines	3+1	2+2	Theory of El. Engineering	3+2	-
Hydraulic Machines	2+1	2+1	Electrical Machines	4+4	-
Electrical Measurements	2+3	2+3	Electrical Facilities	2+3	-
El. Grids and Installations	4+2	-	Electrical Machines Testing	2+3	1+3
Electrical Machines	3+2	2+4	Electric Power Transmission	4+3	-
Low-voltage Current	3+2	-	Power Routers	2+0	-
Theory of El. Engineering	-	3+2	High Voltage Engineering	-	2+3
Electrical Facilities	-	2+3	Organization	-	2+0
			Elective course	<i>min 13 hours</i>	
			El. Grids and Installations	-	3+2
			Electrical Facilities, Sel. Chap.	-	3+2
			El. Power Transm., Sel. Chap.	-	3+2
			Electrical Machines, Sel. Chap.	-	3+2
			Theory of Electrical Engineering	-	3+2
			Motor Drives	-	3+2
			Regulation Techniques	-	3+2
			Construction of El. Devices	-	2+1
			Economy of Electrical Energy	-	2+1
			Power Routers, Sel. Chap.	-	2+1
			Electrical Lighting	-	2+1
			Electric Traction	-	2+1
			Electric Power Dispatch	-	2+1
			Electrothermy	-	2+1
			Power Transmission Stability	-	2+1

Study profile: Electrical Power Engineering – ETF-2, academic year 1967/68

Third year			Fourth year		
Required courses	Semester		Required courses	Semester	
	Winter	Summer		Winter	Summer
Theory of El. Engineering	2+2	4+2	Electrical Facilities	2+3	3+2
Electrical Machines	4+2	3+2	Electric Power Transmission	4+4	4+2
Electronic Circuits	2+2	-	High Voltage Engineering	2+2	-
Hydraulic Machines	3+1	-	Electrical Machines	2+2	-
Mechanical Technology	2+0	-	Regulation Techniques	3+2	-
Machine Elements	3+3	-	Fundamentals of Economy	2+0	2+0
Fundamentals of Sociology	2+2	2+2	Overvoltage Protection	-	2+2
Electronic Computers	2+2	-	Relay Protection	-	2+1
Electrical Facilities	-	2+3	Elective course	<i>min 12 hours</i>	
Electric Power Distribution	-	4+2	Potential Fields	-	2+1
Heat Machines	-	4+2	Measuring Techniques	-	2+3
			Motor Drives	-	2+1
			Regulation in Power Plants	-	2+1
			Organization Methods	-	2+1
			Electrothermy	-	2+1
			Electrical Devices	-	4+2
			Laboratory of El. Machines	-	2+4
			Construction of Rot.Machines	-	4+2
			Power Routers	-	4+0
			Nuclear Power Plants	-	3+2
			Load Distribution in EPS	-	2+1
			Overhead Lines	-	2+1
			Operational Safety	-	2+1
			Bulk Energy Transfer	-	2+1
			Power Grid Regulation	-	2+1
			Aux. Devices in Power Plants	-	2+1
			Electrical Lighting	-	2+1
			Networks and Installations	-	2+1
			Impulse and Digital Electronic	-	2+2

Study profile: Electrical Power Engineering – ETF-3, academic year 1970/71.

Third year			Četvrta godina		
Required courses	Semester		Required courses	Semester	
	Winter	Summer		Winter	Summer
Energy Fundamentals	2+0+0+0	-	Electrical Energy Production	4+2+2+0	-
Power Transf. and Machines	4+2+0+0	-	Electrical Energy Production	0+0+0+1	-
Electrical Power Lines	3+0+1+0	-	High Voltage Networks	4+0+1+0	-
Electrical Power Lines	0+0+0+2	-	High Voltage Networks	0+0+0+1	-
Electrical Fields and Circuits	4+4+0+0	-	Electric Motors	2+0+0+0	-
Electrical Circuits	2+1+2+0	-	High Voltage Engineering	4+0+2+0	-
Electronic Computers	2+0+2+0	-	Regulation Techn. and Automation	2+1+0+0	2+1+1+0
El. Facilities and Devices	-	4+1+3+0	Electric Power Systems	-	2+0+1+0
El. Facilities and Devices	-	0+0+0+1	Relay and Measuring Techn.	-	3+0+2+0
Synch. Machines and Routers	-	3+1+0+0	Relay and Measuring Techn.	-	0+0+0+1
Synch. Machines and Routers	-	0+0+0+1	Construction program	-	0+0+5+0
LV Grids and Installations	-	4+0+1+0	Fund. of Ind. Sociology	2+0+0+0	-
LV Grids and Installations	-	0+0+0+2	Fundamentals of Economy	2+0+0+0	-
Fund. of Mechanical Construct.	-	2+1+0+0	Elective course	<i>min 12 hours</i>	
Fund. of Mechanical Construct.	-	2+0+0+0	Remark: Because of their large number elective courses are not listed.		
Fundamentals of Ind. Sociology	-	2+0+0+0			
Fundamentals of Economy	-	2+0+0+0			
Industrial Practices	-	yes			

Study profile: Electrical Power Engineering – ETF-4, academic year 1980/81

Third year			Fourth year: Construction and Operation of EPS		
Required courses	Semester		Required courses	Semester	
	Winter	Summer		Winter	Summer
Theory of El. Engineering	3+3+0+0	-	Selected Chap. of Mathematics	3+2+0+0	-
Energy processes	4+3+0+0	-	Power Plants	2+0+2+0	-
Power Transformers	2+2+0+0	-	Power Plants	0+0+0+1	-
Fund. of Mech. Constructions	2+1+0+0	-	Electric Power Networks I	0+0+0+1	-
Electronic Circuits	3+1+1+0	-	Synchronous Machines	0+0+0+1	-
Economics in Engineering	2+0+0+0		Electric Power Networks II	3+1+1+0	-
Foreign Language	2+0+0+0	2+0+0+0	Electric Power Networks II	0+0+0+1	-
Electrical Facilities	-	4+1+3+0	High Voltage Engineering	3+0+2+0	-
Electrical Facilities	-	0+0+0+1	Electric Motors	2+0+1+0	-
Power Electronics		2+0+1+0	Electric Power Systems	3+0+1+0	-
Synchronous Machines	-	3+1+0+0	Electric Power Systems	0+0+0+1	-
Electric Power Networks I	-	4+1+1+0	Electric Power Networks III	-	4+0+1+0
Regulation Techniques	-	4+2+1+0	Relay Protection	-	3+1+2+0
Industrial Practices	-	da	Construction program	-	0+0+5+0
			Elective course	<i>min 13 hours</i>	

Fourth year: Control of EPS		
Selected Chap. of Mathematics	3+2+0+0	-
Power Plants	2+0+2+0	-
Power Plants	0+0+0+1	-
High Voltage Engineering	3+0+2+0	-
Electric Power Networks I	0+0+0+1	-
Synchronous Machines	0+0+0+1	-
Electric Motors	2+0+1+0	-
Digital Control	3+2+2+0	-
Regulation in EPS	2+0+1+0	-
Control in EPS	-	3+0+2+0
Control in EPS	-	0+0+0+1
Relay Protection	-	3+1+2+0
Construction program	-	0+0+5+0
Elective course	<i>min 13 hours</i>	

Fourth year: Power Engineering		
Selected Chapters of Mathematics	3+2+0+0	-
Power Plants	2+0+2+0	-
Power Plants	0+0+0+1	-
High Voltage Engineering	3+0+2+0	-
Electric Power Networks I	0+0+0+1	-
Synchronous Machines	0+0+0+1	-
Electric Motors	2+0+1+0	-
Electric Power Systems	3+0+1+0	-
Electric Power Systems	0+0+0+1	-
Nuclear Physics Introduction	2+2+0+0	-
Energy Sources	-	3+2+0+0
Energy Sources	-	0+0+0+1
Energy Systems and Balance	-	3+2+0+0
Energy Systems and Balance	-	0+0+0+1
Operations Research	-	2+2+0+0
Economics of Energy	-	2+2+0+0
Energy and Environment	-	2+1+0+0
Construction program	-	0+0+7+0

Study profile: Nuclear Power Engineering – ETF-4, academic year 1980/81

Third year			Fourth year		
Required courses	Semester		Required courses	Semester	
	Winter	Summer		Winter	Summer
Nuclear Physics Introduction	2+2+0+0	-	Sel. Chap. of Mathematics	3+2+0+0	-
Theory of Electrical Engineering	3+3+0+0	-	Electronic Circuits	3+1+1+0	-
Energy processes	4+3+0+0	-	Lab. of Nuclear Engineering	0+0+2+0	-
Power Transformers	2+2+0+0	-	Reactor Heat Processes	3+2+0+0	-
Fund. of Mech. Constructions	2+1+0+0	-	Power Plants	2+0+2+0	-
Reactor Kinetics and Dynamics	3+1+0+0	3+2+0+0	Power Plants	0+0+0+1	-
Foreign Language	2+0+0+0	2+0+0+0	Nuclear fuel Cycles	2+1+0+0	-
Electrical Facilities	-	4+1+3+0	Reactor Materials	2+1+0+0	-
Electrical Facilities	-	0+0+0+1	Economics in Engineering	2+0+0+0	-
Synchronous Machines	-	3+1+0+0	Power Electronics	-	2+0+1+0
Lab. of Nuclear Engineering	-	0+0+3+0	Motor Drives	-	3+0+1+0
Regulation Techniques	-	4+2+1+0	Safety and Regulation	-	4+2+0+0
Industrial Practices	-	yes	Nuclear Power Plants	-	3+1+0+0
			Nuclear Power Plants	-	0+0+0+1
			Control and Regulat. in NPP	-	3+0+2+0
			Radiation Eff. and Protection	-	2+0+2+0
			Nuclear Reactor Safety	-	2+0+1+0

Study profile: Electrical Power Engineering (module Energy Systems) – FER-1, academic year 1994/95.

Undergraduate study – third year			Graduate study – first year		
Required courses (ECTS)	Semester		Required courses (ECTS)	Semester	
	Winter	Summer		Winter	Summer
Energy processes (6)	4+2+0	-	Electrical Facilities (7)	4+1+1	-
Electrical Mach. and Transf. (7)	4+1+1	-	Electric Power Networks (6)	4+1+0	-
Nuclear Power Eng. Intro. (5)	4+0+0	-	Numerical Analysis. of Electric Power Systems (7)	4+1+1	-
Theory of El. Engineering (6)	3+2+0	-	High-voltage Engineering (5)	3+0+1	-
Social course (2+2)	2+0+0	2+0+0	Social skills course (2)	2+0+0	-
Power Electronics Princip. (5)	-	2+1+1	Power Plants (5)	-	2+1+1
Regulation Techniques (7)	-	3+1+1	Power System Control (5)	-	2+1+1
Fund. of Mechatronics (7)	-	3+1+1	Power Syst. Protect. and Automatization (5)	-	2+1+1
Electric Power Transmis. (5)	-	3+1+0	Economics (2)	-	2+0+0
Selection of elective courses (at least 8 ECTS)			Seminar (7)	-	1+0+3
			Selection of elective courses (at least 9 ECTS)		
Graduate study – second year			<i>Remark: Because of their large number elective courses are not listed.</i>		
Required courses (ECTS)	Semester				
	Winter	Summer			
Electric Power System Operation and Control (6)	3+0+2	-			
Graduation Thesis (18)	1+0+14	-			
Selection of elective courses (at least 6 ECTS)					

Study profile: Electrical Power Engineering (module Energy Technology) – FER-1,
academic year 1994/95.

Undergraduate study – third year			Graduate study – first year		
Required courses (ECTS))	Semester		Required courses (ECTS)	Semester	
	Winter	Summer		Winter	Summer
Energy processes (6)	4+2+0	-	Electrical Facilities (7)	4+1+1	-
El. Machines and Trans. (7)	4+1+1	-	Electric Power Networks (6)	4+1+0	-
Nucl. Power Eng. Intro. (5)	4+0+0	-	Rad. Effects and Protection (6)	3+1+1	-
Renew. Energy Resources (6)	3+0+1	-	Nuclear fuel Cycles and Reactor Materials (6)	3+1+0	-
Social course (2+2)	2+0+0	2+0+0	Social skills course (2)	2+0+0	-
Princ. of Power Electronics (5)	-	2+1+1	Power Plants (5)	-	2+1+1
Regulation Techniques (7)	-	3+1+1	Energy and Environment (4)	-	2+1+0
Fund. of Mechatronics (7)	-	3+1+1	Nuclear Power Plants (6)	-	4+1+0
Heat transfer (5)e	-	3+1+0	Economics (2)	-	2+0+0
Elective courses selection of at least 8 ECTS			Seminar (7)	-	1+0+3
Graduate study – second year			Elective courses selection of at least 9 ECTS		
Required courses (ECTS)	Semester		<i>Remark: Because of their large number all elective courses are not listed.</i>		
	Winter	Summer			
Safety of Nuclear Plants (6)	3+1+0	-			
Graduation Thesis (18)	1+0+14	-			
Elective courses selection of at least 6 ECTS					

Study profile and module: Electrical Power Engineering – FER-2,
academic year 2005/06.

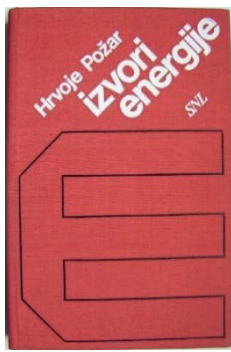
Undergraduate study module – third year electrical Power Engineering			Graduate study module – first year Electrical Power Engineering		
Required courses (ECTS)	Semester		Required courses (ECTS)	Semester	
	Winter	Summer		Winter	Summer
Automatic Control (5)	4+0+1	-	Power Systems Analysis (5)	3+2+0	-
Electric Facilities (4)	3+2+1	-	Power Sys. Dyn. and Con. (5)	3+1+0,4	-
Electromech. and El. Conv. (4)	3+1,3+1	-	Energy Conversion (5)	3+1+0	-
Electronic Communications (5)	4+0+1	-	Economics of Energy (5)	-	3+0,3+0
Sust. Develop. and Environ.(2)	2+0+0	-	High Voltage Engineering (5)	-	2,6+0,4+0
Project (6)	0+0+0	-	Required courses (ECTS)	Winter	Summer
Information Theory (4)	3+0+1	-	Lab. of El. Power Eng. 1 (5)	-	2+0+4
BSc Thesis (12+12)	0+0+0	0+0+0	Seminar (3)	-	2+0+0
Trans. and Dist. of El. Power (4)	-	3+2+0,8	Lab. of El. Power Eng. 2 (3)	-	1+0+2
Commercial Law (2)	-	2+0+0	Specialization courses 12 ECTS		
Selection of elective courses of at least 12 ECTS			Mathematics and science 8 ECTS		
Graduate study module – second year Electrical Power Engineering			Humanistic or social courses 4 ECTS		
Required courses (ECTS)	Semester		<i>Remark: Because of their large number elective courses, specialization courses, courses of mathematics and science and humanistic or social courses are not listed.</i>		
	Winter	Summer			
Project (8)	0+0+0	-			
Graduation Thesis (30+30)	0+0+0	0+0+0			
Selection of elective courses (at least 12 ECTS)					
Specialization courses of total 8 ECTS					
Humanistic or social skills courses 2 ECTS					

APPENDIX II – LIST OF PUBLISHED BOOKS

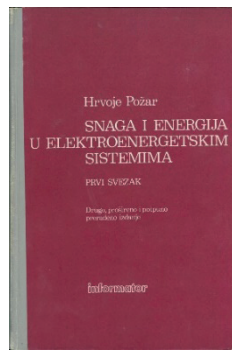
1. Hrvoje Požar. “*Economic dispatch in power system: foundations for a practical work of power system operators*” (original in Croatian: Ekonomična raspodjela opterećenja u elektroenergetskom sistemu: osnovi za praktičan rad elektroenergetskih dispečera), Školska knjiga, Zagreb, 1953.
2. Hrvoje Požar. “*Power and energy in composite power systems*” (original in German: Leistung und Energie in Verbundsystemen, Springer-Verlag), Wien, Austria, 1963.
3. Hrvoje Požar. “*Power and energy in power systems*” (original in Croatian: Snaga i energija u elektroenergetskim sistemima), Zajednica jugoslavenske elektroprivrede, Beograd, 1966.
4. Hrvoje Požar. “*High-voltage electric facilities*” (original in Croatian: Visokonaponska rasklopna postrojenja), Tehnička knjiga, Zagreb, 1967.
5. Milan Šodan. “*Automation using logic circuits*” (Original in Croatian: Automatizacija logičkim sklopovima, Školska knjiga), Zagreb, 1973.
6. Hrvoje Požar. “*High-voltage electric facilities – 2nd edition*” (Original in Croatian: Visokonaponska rasklopna postrojenja, Drugo izdanje), Tehnička knjiga, Zagreb, 1973.
7. Božidar Stefanini. “*Fortran – programming course book*” (Original in Croatian: Fortran - udžbenik programiranja), Tehnička knjiga, Zagreb, 1973.
8. Božidar Stefanini, Srđan Babić, Mirjana Urbiha-Feuerbach. “*Matrix methods in power system network analysis*” (Original in Croatian: Matrične metode u analizi električnih mreži), Školska knjiga, Zagreb, 1975.
9. Božidar Stefanini. “*Fortran V – fundamentals*” (Original in Croatian - Fortran V, osnovni tečaj), Školska knjiga, Zagreb, 1975.
10. Hrvoje Požar. “*Power engineering fundamentals – Volume 1*” (Original in Croatian – Osnove energetike, Prvi svezak), Školska knjiga, Zagreb, 1976.
11. Hrvoje Požar. “*Power engineering fundamentals – Volume 2*” (Original in Croatian – Osnove energetike, Drugi svezak), Školska knjiga, Zagreb, 1978.
12. Hrvoje Požar. “*High-voltage electric facilities – 3rd edition*” (Original in Croatian: Visokonaponska rasklopna postrojenja, Treće popravljeno izdanje), Tehnička knjiga, Zagreb, 1978.
13. Hrvoje Požar. “*Energy sources*” (Original in Croatia: Izvori energije), Sveučilišna naklada Liber, Zagreb, 1980.
14. Hrvoje Požar. “*Power and energy in electric power systems – Volume 1 - 2nd edition*” (Original in Croatian: Snaga i energija u elektroenergetskim sistemima, Svezak 1, Drugo prošireno i potpuno prerađeno izdanje), Informator, Zagreb, 1983.
15. Hrvoje Požar. “*High-voltage electric facilities – 4th edition*” (Original in Croatian: Visokonaponska rasklopna postrojenja, Četvrto popravljeno izdanje), Tehnička knjiga, Zagreb, 1984.
16. Hrvoje Požar. “*Power and energy in electric power systems – Volume 2 - 2nd edition*” (Original in Croatian: Snaga i energija u elektroenergetskim sistemima, Drugi svezak, Drugo prošireno i potpuno prerađeno izdanje), Informator, Zagreb, 1985.
17. Mario Padelin. “*Lightning protection*” (Original in Croatian: Zaštita od groma), Školska knjiga, Zagreb, 1987.
18. Hrvoje Požar. “*Power engineering fundamentals 1, 2nd edition*” (Original in Croatian: Osnove energetike 1, Drugo dopunjeno i izmjenjeno izdanje), Školska knjiga, Zagreb, 1992.
19. Hrvoje Požar. “*Power engineering fundamentals 2, 2nd edition*” (Original in Croatian: Osnove energetike 2, Drugo dopunjeno i izmjenjeno izdanje), Školska knjiga, Zagreb, 1992.
20. Hrvoje Požar. “*Power engineering fundamentals 3, 2nd edition*” (Original in Croatian: Osnove energetike 3, Drugo dopunjeno i izmjenjeno izdanje), Školska knjiga, Zagreb, 1992.
21. Danilo Feretić. “*Nuclear power engineering introduction*” (Original in Croatia: Uvod u nuklearnu energetiku), Školska knjiga, Zagreb, 1992.
22. Danilo Feretić, Nikola Čavlina, Nenad Debrecin. “*Nuclear power plants*” (Original in Croatian: Nuklearne elektrane), Školska knjiga, Zagreb, 1995.
23. Danilo Feretić, Željko Tomšić, Dejan Škanata, Nikolna Čavlina, Damir Subašić. “*Power plants and environment*” (Original in Croatian: Elektrane i okoliš), Element, Zagreb, 2000.
24. Srđan Skok. “*Uninterruptable power supply*” (Original in Croatian: Besprekidni izvori napajanja), Kigen, Zagreb, 2002.

25. Zoran Vukić, Ljubomir Kuljača, Dali Donlagić, Sejid Tešnjak. "Nonlinear Control Systems", Marcel Dekker, Inc., New York-Basel, 2003.
26. Srđan Skok. "DC systems and circuits in power facilities" (Original in Croatian: Sustavi istosmjernih razvoda u elektroenergetskim postrojenjima), Kigen, Zagreb, 2007.
27. Vladimir Mikuličić, Zdenko Šimić. "Reliability, availability and risk assessment models in power systems" (Original in Croatian: Modeli pouzdanosti, raspoloživosti i rizika u elektroenergetskom sustavu), Kigen, Zagreb, 2008.
28. Sejid Tešnjak, Eraldo Banovac, Igor Kuzle. "Electricity market" (Original in Croatian: Tržište električne energije), Graphis, Zagreb, 2009.
29. Danilo Feretić, Željko Tomšić, Dejan Škanata, Nikolna Čavlina, Damir Subašić, "Power plants and environment – 2nd edition" (Original in Croatian: Elektrane i okoliš, Drugo izdanje), Element, Zagreb, 2009.
30. Danilo Feretić. "Nuclear power engineering introduction – 2nd expended edition" Uvod u nuklearnu energetiku, Drugo dopunjeno izdanje, Školska knjiga, Zagreb, 2010.
31. Ivo Uglešić, Milivoj Mandić. "Electric Traction Power Supply" (Original in Croatian: Napajanje električne vuče), Graphis, Zagreb, 2014.
32. Amir Tokić, Viktor Milardić. "Quality of electric power supply" (Original in Bosnian: Kvalitet električne energije), Printcom, Tuzla, 2015.

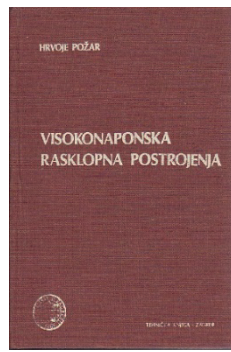




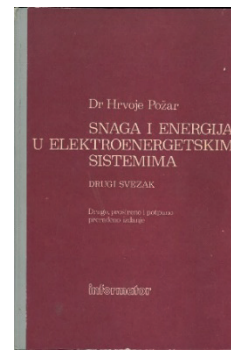
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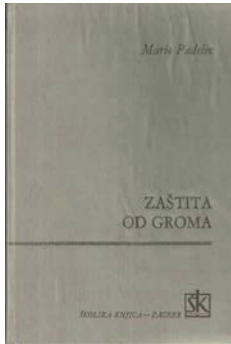
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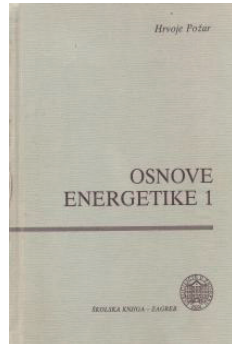
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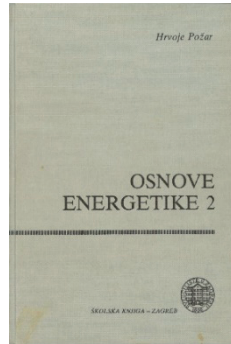
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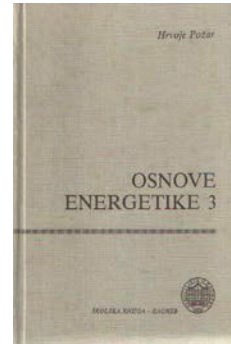
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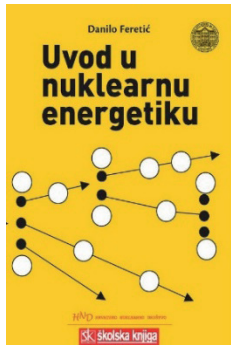
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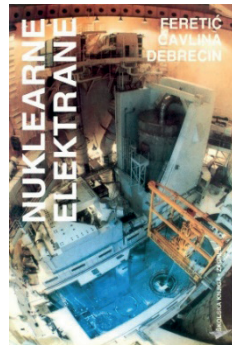
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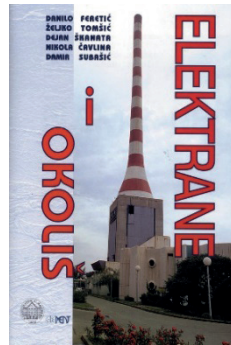
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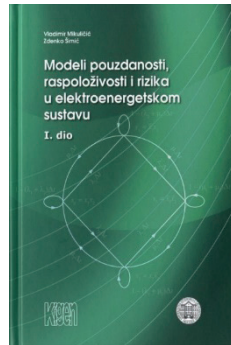
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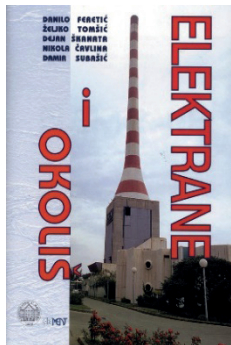
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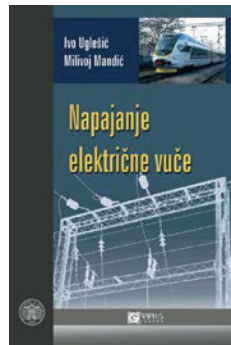
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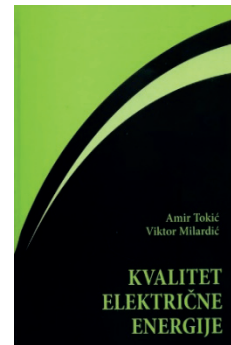
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APPENDIX III – LIST OF THE DEPARTMENT LECTURERS AND PROFESORS

NAME	TITLE	PERIOD	FILED
Dr. sc. Srđan Babić (1935)	associate professor	1961-2000	transmission networks, power system stability
Dr. sc. Nikola Čavlina (1950)	full professor	1975-2017	nuclear power plant safety and control
Dr. sc. Nikola Čupin (1938)	associate professor	1964-1973	electrical facility design
Dr. sc. Nenad Debrecin (1953)	full professor	1975	nuclear power plants, heat transfer
Dr. sc. Marko Delimar (1974)	associate professor	1997	transmission networks, power system analysis
Mladen Dokmanić, dipl. ing. (1908-1980)	associate professor	1952-1978	transmission networks, el. grids and installations
Dr. sc. Danilo Feretić (1930)	professor emeritus	1982-2002	nuclear power plants, heat transfer
Dr. sc. Vjekoslav Filipović (1935-2012)	full professor	1961-2005	electrical facilities, power system optimisation
Dr. sc. Davor Grgić (1959)	associate professor	1990	nuclear power plants safety
Dr. sc. Juraj Havelka (1974)	assistant professor	1998	power system protection, SCADA
Dr. sc. Zdravko Hebel (1943-2017)	full professor	1966-2013	transmission networks, power system analysis
ing. Juro Horvat (1882-1954)	professor	1932-1947	electricity generation, transients in el. devices
Dr. sc. Ivo Hrs (1937-1998)	assistant professor	1960-1966	high voltage engineering
Slavko Krajcar (1951)	full professor	1974	electrical facility design, distribution networks
Igor Kuzle (1967)	professor	1992	power systems dynamics and control, smart grids
Toussaint Levičnik, dipl.ing. (1903-1984)	senior associate	1958-1974	electrical facilities
Boris Markovčić, dipl. ing. (1915-2006)	senior lecturer	1952-1957	high voltage engineering, bulk power transmission
Dr. sc. Ante Marušić (1952)	full professor	1977	power system protection and local control
Dr. sc. Vladimir Mikuličić (1944)	full professor	1970-2014	energy conversion, el. power system reliability
Dr. sc. Viktor Milardić (1971)	associate professor	1998	high voltage engineering, electromag. compatibility
Dr. sc. Zoran Morvaj (1957)	assistant professor	1981-1992	energy efficiency, expert systems
Dr. sc. Mario Padelin (1922-1984)	full professor	1957-1984	high voltage techniques, high voltage protection
Dr. sc. Ivica Pavić (1962)	professor	1987	transmission networks, power system analysis
Academician Dr. sc. Hrvoje Požar (1916-1991)	full professor	1951-1984	Electric power systems, electric power engineering
Dr. sc. Božidar Stefanini (1913-1991)	full professor	1950-1984	transmission networks, power system stability
Dr. sc. Zdenko Šimić (1964)	associate professor	1988-2015	electric power engineering, power systems reliability
Dr. sc. Davor Škrlec (1963)	full professor	1987-2014	el. distribution systems, GIS
Dr. sc. Milan Šodan (1927)	full professor	1965-1996	power system control, automation
Dr. sc. Sejid Tešnjak (1949)	full professor	1973-2017	power plants, power system dynamics and control
Dr. sc. Tomislav Tomiša (1954)	full professor	1977	power system automation
Dr. sc. Željko Tomšić (1957)	associate professor	1991	energy management, power system generation planning
Mr. sc. Vladimir Tuk (1943-1997)	assistant	1967-1997	high voltage engineering
Dr. sc. Ivo Uglešić (1952)	full professor	1976	high voltage engineering, electrical railways
Mr. sc. Mirjana Urbuha-Feuerbach (1926-2010)	scientific assistant	1960-1986	power system analysis, overhead lines
Željko Zlatar (1925-2006)	assistant professor	1959-1995	power system protection
Vladimir Žepić (1894-1971)	associate professor	1948-1952	generation, transmission networks