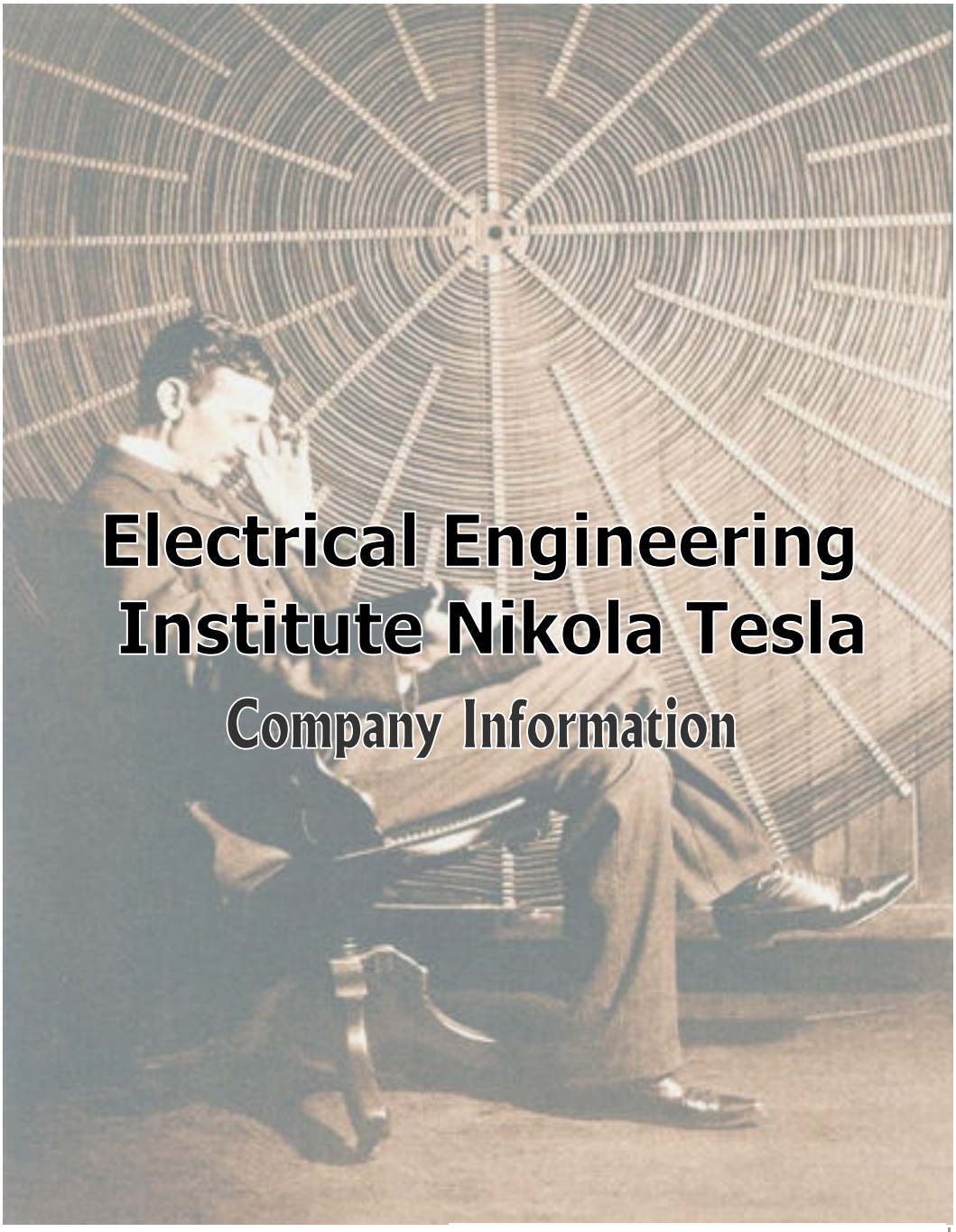
Electrical Engineering Institute **Nikola Tesla**



Electrical Engineering Institute Nikola Tesla

Company Information

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GENERAL

In the year 2006 it has been 150 years since the birth of Nikola Tesla scientist, inventor and visionary, whose work have changed the world and significantly contributed development and speed progress of manhood and electrical engineering. At the same time, it has been 70 years since the president of Serbian Royal Academy of sciences, Mr Bogdan Gavrilovic, declared the establishment of Institute "Nikola Tesla" - "as a temple of science in the glory of his name and eternal beauty of his work".

In its history that lasts more than seven decades, Institute passed through great number of changes and transformations in order to accommodate to changes in its surrounding and during that time changed its name and working area. Today, Electrical Engineering Institute "Nikola Tesla" is independent scientific - research joint - stock organization (98% owned by state, 2% owned by small shareholders) which activity covers a wide spectra of problems in the area of production, transmission, distribution and implementation of electrical energy.

Nikola Tesla Institute Building
At Koste Glavinića 8a St. in Belgrade

R&D PROFILE

Our R&D profile presents synthesis of scientific and expert knowledge across a wide spectrum of disciplines: energy, high voltage, high power electronics, automation, computer science, measurement, information systems, and software engineering.

By synthesis of scientific and engineering knowledge and experience Institute become admirable and authoritative scientific institution in our country and abroad in the area of electrical engineering, always ready to answer to the challenges of modern science and at the same time to respond to the necessities of domestic economy. It is verified by quality certificate that is obtained in the year 2001.

LINKS TO INDUSTRY

Institute's strategic partners are "Electric Power Industry of Serbia" and "Serbian Transmission System", thus contributing to the solution of current problems in the electrical industry in Serbia, and at the same time directing future development of those technologically very complex systems, using the modern activeness of the science in this area.

PEOPLE

Institute skilled and innovative R&D workforce assembles 130 researchers (14 PhDs, 8 MSc and 65 BSc) that have mainly graduated from University of Belgrade, School of Electrical Engineering, and got their Master of Science and PhD qualifications either in Belgrade or in prominent European and global university centers.

ORGANIZATION

Research activities in the Institute are organized in four scientific - research departments :

Power System Department

Automation and Control Department

Electric Power Facilities Department

Electrical Measurements Department

Laboratory for testing and calibration

in which researchers are working on the problems of development and architecture of power system, its exploitation and control in integrated and deregulated power surrounding, implementation of new technologies, automation and new functional solutions in power system and its plants, development and testing of high and low voltage equipment that is used in production, transmission and distribution of electrical energy, development and implementation of measurements methods and measurements devices, control of quality parameters, etc

Beside metrological laboratory in the Institute are organized and six certified testing laboratories: laboratory for electric equipment testing, laboratory for earthling, lightning and electrical installation testing, laboratory for thermo graphical testing, laboratory for insulation systems testing, laboratory for insulation oils testing and laboratory for materials and products and protection accessories testing.

Power System Department

The **Power System Department** activities includes research of different phenomena related to the generation, transmission, distribution and utilization of electrical power.

The main goal of these researches is advancing of development, operation and management of modern large power systems, based on introducing of new technologies, asset management techniques and applying of power energy software solutions and advanced tools. The result should ensure reliability, quality and safety of energy flows, as well as efficient operation of networks though information management.

The **Power System Department** is organized into four following divisions:

The Sector of **Power System Analysis** includes: modeling of network and all network fundamental components under both steady-state and dynamic conditions, power flow analysis, short circuit analysis, short-term, mid/long term dynamics and stability, energy efficiency analysis in transmission, distribution and industrial networks, methods for optimizing the technical and economic performance of the system, techical and economical studies for finding optimal voltage levels and equipment characteristics in transmission and distribution networks, quality and security analysis of electric power delivery systems, development and methods and algorithms required for analyzing modern intercinnested power systems, development and aplication of experts systems and artificial inteligence in electric power system, application of advanced techiques in power systems analysis, the deregulation of energy markets and operation of systems in open new markets conditions, etc.

The Sector of **Power System Development** includes: analysis of characteristics of consumption and forecasting of power demand (long, medium and short terms), feasibility studies and long term system development planning, economic analysis-optimizing the quality and security improvement alternatives for a

system perspective, network planning and design in the vertically integated systems, development of optimization mathods and their application in power systems design and their components, probability methods and their application in planning of development of power systems and their elements, optimal Var planning, reliability analysis of exsisting and perspective systems solutions, expansion planning of transmission and distribution systems in the deregulated enviroment.

The Sector of **Power System Management and Control** included: data base for power systems application, security analysis-preventive and emergency control, voltage and reactive power control managinig of power systems during and after accident regimes, optimal load flow, economic dispatching, protection adjustment, coordination of power plant operation with power system operation in a restructured and comperirive utility environment, security, monitoring and control in deregulated power systems, system frequency control, power and demand side management, etc.

The Sector of **Special Services** includes: strategic study of development and design of power systems, engineering comsultancy services for the design of grid, expertise, specific software for power systems analysis, etc

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Automation and Control Department

The activities of the **Automation and Control Department** include development, research and testing of Power Electronics and Automation Control.

The field of Power Electronics includes research, development and manufacture of power electronics devices: recitifiers, inverters, choppers, static switches, uninterruptible power supply systems and frequency converters.

The field of Control in Power Systems includes analysis, research, design and testing of voltage control and reactive power, control of frequency and active power, real time control, automartion and testing of power generating plants.

The field of Automation and Control includes development, testing and manufacture of :analog and digital controllers, industrial control, systems, exitation control systems, turbine governing systems, protection devices and controlled electrical drives.

The field of Special Services includes research, development and manufacture of : special control equipment, special transducers, microprocessor based systems for supervision and control of plants and processes and consulting services

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Electiric Power Facilities

The **Electiric Power Facilities Department** focusses on following activities.

High Voltage Technique includes calculation, laboratory analisys and field testing of voltage and current transient processes in power systems and industrial power plants for all voltage levels.

Selection and coordination of insulation, surge and lightning protection for various facilities.

Acceptance and preventive - diagnostic examination of high voltage equipment.

Measurements of electric and magnetic fields in very high voltage and current networks.

High voltage laboratory with suitable high voltage generators, voltage and current surge generators, as well as high quality equipment in the microsecond range enable the Center to carry out the examinarion and analysis of transient processes.

Thermographical Research of plants, overhead and underground cable lines and equipment with important influence in preventive maintenance in power systems.

Earthing and Safety include programming of optimal solutions, design and testing of earthing systems in power plants and columns of overhead power lines at all voltage levels in earth connection and lightning conditions, as well as plant commissioning from the safety aspect.

Cable Technique includes testing and control of heating processes and optimal solutions in design and exploatation of cable networks.

Special Devices include manufacture of new types of modular, programmable and multipurpose microprocessor based recorders of transient processes on plants and industry.

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Electrical Measurements Department

The main area of activities of the **Electrical Measurements Department** is electrical measurements of electrical, magnetic and non electrical quantities.

Development and Application of Measurements Methods

Theoretical studies are the basis for effecting the measurement methods and laboratory measurements thereby creating preconditions for applied measurements, as well as the design and manufacture of measurement devices and systems.

Metrology

There is a long experience in development and maintenance of base measures of electrical and magnetic quantities. Development and application of current comparators, base value of magnetic fields and mechanical force and mass are the result of this experience.

Measurements in Electric Power Industry

Testing of insulation systems in power generating plants, with the examination of phisical and chemical properties of insulating oils, as well as production of devices for testing of relay protection systems and measurement and power transformers.

Special Devices

In its work, the Center uses modern methods and techonologies, such as application of computers and microprocessor and transputer based elements, enabling it to meet special request from its clients.

Due to the quality, a close cooperation and export to various European, Asian and African countries has been established

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Laboratory for testing and calibration

Laboratory for testing and calibration is dedicated to bringing the highest quality and competent service to the clients according to SRPS ISO IEC 17025:2006 standards requirements.

Laboratory for testing and calibration in Electrical engineering institute Nikola Tesla is accredited by the Association for laboratory accreditation of Serbia (ATS). This means that we are certified to perform 114 different types of testing and calibrations.

Some of our Laboratory's work specialties and the main areas of expertise are as follows:

1. **MEASUREMENTS AND TESTINGS OF GROUNDING SYSTEMS, LOW VOLTAGE ELECTRICAL INSTALLATIONS AND LIGHTNING PROTECTION SYSTEMS**

large grounding systems in electric power facilities: ground impedance, touch and step voltages, earth resistivity;

low voltage electrical installations: earth loop impedance, insulation resistance, continuity;

lightning protection systems: grounding resistance, equipotentiality.

2. **TESTING OF ELECTRICAL EQUIPMENT, APPLIANCES, MATERIALS AND PROTECTIVE DEVICES**

switchgears (dielectric and thermal characteristics)

surge arresters (determination of the lightning impulse sparkover voltage test, power frequency sparkover voltage test, power frequency withstand test, AC and DC leakage current measurements, 5 kV insulation resistance test, a non-standard

current impulse test, and finally the partial discharge voltage measurements

low voltage and high voltage circuit breakers (thermal characteristics, power frequency voltage withstand test, lightning impulse voltage withstand test)

electrical power cables and appliances (dielectric and thermal characteristics)

protective equipment (insulation gloves and boots, insulation benches, voltage detectors, insulation sticks).

3. THERMOGRAPHIC INSPECTION

inspection of electrical equipment in power system installations at all voltage levels (detection and analysis of irregularities manifested through increased heating)

stator core imperfection detection on power generators using rated induction method.

4. INSULATING OIL AND PAPER

Chemical laboratory actively contribute to the work in IEC TC 10 and CIGRE SC A2 and SC D1. In the scope of the work it performs analysis of new mineral insulating oils according to IEC 60296 spec., analysis transformer oils in service in electrical equipment, power and instrument transformers, OLTC, switchgears, analysis of new and aged insulating paper.

Condition Based Monitoring (CBM) of electrical equipment is derived from oil analysis and has been performed in the Institute during last 4 decades. It includes following measurements:

- Dissolved gas analysis (DGA) and free gas analysis according to IEC 60567 and IEC 60599
- Determination of water content in the oil using Karl Fisher according to IEC 60814

- Determination of furan compounds in the oil according to IEC 61198
- Determination of physical, chemical and electrical oil properties according to IEC 60422
- Determination of antioxidants and metal passivators in the oil according to IEC 60666
- Determination of particles in the oil according to IEC 60970 and ISO 4406
- Determination of oil oxidation stability according to IEC 61125
- Determination of corrosive sulphur in the oil according to IEC 62535, DIN 51353 and ASTM 1275
- Determination of DBDS according to IEC 62697
- Determination of aromatic content in the oil according to IEC 60590
- Determination of PCB in insulating oils according IEC 61619

Condition based assessment of power transformers is performed in synergy with results on electrical measurements.

Other tests on oil and paper insulation, laboratory simulations for optimization of on site processes:

- Laboratory simulation of oil reclamation for optimization of on*site process, determination of optimum process parameters: temperature, number of cycles, type and mass of sorbent needed, expected oil results after reclamation, quantity of antioxidant needed for reinhibition.
- Laboratory simulation of addition of metal passivators in power transformers

- Determination of optimum metal passivator quantity needed for complete inhibition of copper sulphide formation
- Simulation of service behavior, related to potential side effects (stray gassing and changed equilibrium of furans)
- Transformers factory Inspection, post-mortem and failure investigation for evaluation of consumed and remaining life of paper insulation of power transformers:
    - Determination of paper insulation water content according to IEC 60814 and degree of polymerization (Dp) according to IEC 60450
    - SEM/EDX analysis of insulating paper
    - Copper content in the paper using AAS technique

5. ELECTRICAL INSULATION SYSTEM TESTING

Rotating machines

Off-line stator electrical insulation system and stator winding testing – Insulation resistance measurement, DC HiPot test, Capacitance and dissipation factor test, Off-line Partial discharge test, AC HiPot test, Stator Surge test, Winding resistance measurement etc.

Off-line rotor electrical insulation system and winding testing - Insulation resistance measurement, Rotor RSO and Surge test etc.

Power Transformers

Power transformer preventive testing - Insulation resistance measurement, Capacitance and dissipation factor test, HV Bushing Insulation System testing, Leakage Inductance measurement, Turn ratio measurement, Winding resistance

measurement etc.

HV Current and Voltage transformers

HV Current and Voltage preventive testing on site under EM interference - Insulation resistance measurement, Capacitance and dissipation factor test etc.

6. CALIBRATION AND TESTING OF ELECTRICAL MEASURING INSTRUMENTS:

DC voltage measuring instruments: *digital and analogue voltmeters, DC voltage supplies, multifunction instruments (multimeters, calibrators), null indicators, accessories (voltage dividers, probes)*;

DC current measuring instruments: *digital and analogue ammeters, multifunction measuring instruments (multimeters, calibrators), accessories (shunts, dc current clamps), DC current suppliers*;

AC voltage measuring instruments: *digital and analogue voltmeters, AC voltage supplies, multifunction instruments (multimeters, calibrators), null indicators, accessories (voltage dividers, probes)*;

AC current measuring instruments: *digital and analogue ammeters, multifunction measuring instruments (multimeters, calibrators), accessories (shunts, current clamps), AC current suppliers*;

Resistance measuring instruments: *resistors, analogue and digital ohmmeters, analogue and digital conductor meters, resistance decades, resistance measuring bridges (according to Wheatstone and according to Thomson), multifunction instruments, insulation resistance test equipment, ground/earth resistance test equipment.*

The implementation procedures of all the testing and calibration methods guarantee that the projects we deliver not only meet the safety standards and technical

regulations, but are completed successfully and under the tightest schedules.

The main principles of laboratory for testing and calibration are:

following up and satisfying customers demands, existing regulations and standards

planning of all activities with continuous service improvement

constant improvement of tests methods and service quality

aggressive incorporation of innovative technologies into our practice so that our customer get assured that their projects are in the very best hands; data protection

continuous staff training and education stimulation

establishment of inter laboratory cooperation in order to verify our methods and gather broader knowledge

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REFERENCES

Power Systems Department

1. "Selection of the way to reduce distribution network reactive load for 200 Mvar",

   Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade

2. "Study of long-term prospective 110 kV, 35 kV and (partially) 10 kV networks development for the area of "Elektrodistribucija" Užice",

   Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade

3. "Upgrading of reactive power compensation in EES EPS using existing capacitor batteries - the 3rd phase for the area of Public Utility

"Elektrošumadija" Kragujevac, "Elektromorava" Požarevac, "Elektrodistribucija" Užice, "Elektrotimok" Zaječar",

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade

4. "Rationalization of the own electrical energy consumption in Thermal Power Plant "Nikola Tesla B" Obrenovac",

Ordered by: Public Utility "Thermal Power Plant Nikola Tesla", Obrenovac

5. "Study of long-term prospective 110 kV, 35 kV and 10 kV networks development for the area of "Elektrošumadija" Kragujevac",

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade, Public Utility "Elektrošumadija" Kragujevac

6. "Section of study of long-term prospective Serbian transmission network development up to 2020(2025) - Prospective 110, 220 and 400 kV transmission network in Šumadija area of Belgrade",

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade, Public Utility "Elektromreža Srbije", Belgrade

7. "Distribution network further development and medium voltage level selection for the area of Public Utility Elektrosrbija Kraljevo - Distributive area of Kruševac",

Ordered by: Public Utility Elektrosrbija Kraljevo

8. "Distribution network further development and medium voltage level selection for the area of Public Utility Elektrosrbija Kraljevo - Distributive area of Čačak",

Ordered by: Public Utility Elektrosrbija Kraljevo

9. "Power factor correction at the medium voltage side of consumers from Public Utility Belgrade Waterworks",

Ordered by: Serbian Ministry of Science and Environment Protection

10. "Substations 110/X kV optimal choice for reactive power reduction in the amount of additional 200 Mvar from Serbian transmission network point of view (~100 Mvar LV and ~100 Mvar MV reactive power compensation)",

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade

11. "Techno-economical analysis of possibilities and conditions for Serbian transmission network voltage-reactive power state improvement with emphasis to active losses reduction",

Ordered by: Serbian Ministry of Science and Environment Protection

12. "Reactive power sources planning in Serbian transmission network - Phase II",

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade

13. "Revision of Study of supplying 110 kV cable or aerial line TS 220/110/35 kV Kruševac 1 - TS 110/10 kV Kruševac 3 building adequacy",

Ordered by: Public Utility Elektrosrbija Kraljevo

14. "Rationalization of the own electrical energy consumption in Thermal Power Plant "Nikola Tesla A" Obrenovac",

Ordered by: Public Utility "Thermal Power Plant Nikola Tesla", Obrenovac

15. "Study of long-term prospective 10 kV network development for city of Leskovac",

Ordered by: Public Utility "Elektrodistribucija" Leskovac

16. "Technical and economical analysis of building new 35/10 kV substation Mrčajevci",

Ordered by: Public Utility "Elektrosrbija" Kraljevo

17. "Study of long-term prospective Serbian transmission network development up to 2020(2025)",

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade, Public Utility "Elektromreža Srbije", Belgrade

18. "Long-term distribution network development plan up to 2025 in the wider urban area of Public Utility Elektrodistribucija Beograd",

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade, Public Utility "Elektrodistribucija Beograd", Belgrade

19. "Rationalization of the own electrical energy consumption in Thermal Power Plant "Morava" Svilajnac",

Ordered by: Public Utility "Thermal Power Plant Nikola Tesla", Obrenovac

20. "Analysis of generator transformers transmission ratio changing adequacy in HPP Bajina Bašta"

Ordered by: Public Utility "Drinsko limske HE", Bajina Bašta

21. "Specific regimes behavior checking for revitalized generators in HPP Bajina Bašta connected to 220 kV transmission network"

Ordered by: Public Utility "Drinsko limske HE", Bajina Bašta

22. "Analysis of 10-110 kV distribution networks functioning and load forecasting for distribution area of Kraljevo and Vrnjačka Banja",

Ordered by: Public Utility "Elektrosrbija" Kraljevo

23. "Specific regimes behavior checking for revitalized generators in HPP Bajina Bašta connected to 220 kV transmission network - Transient stability analyses"

Ordered by: Public Utility "Drinsko limske HE", Bajina Bašta

24. "The choice and analyses of generator and block-transformer optimal parameters in hydro power plants connected to Serbian 110 kV and 35 kV networks"

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade

25. "Upgrading of reactive power compensation in EES EPS using existing capacitor batteries - the 4th phase for the area of Public Utility "Jugoistok" Niš, i.e. ED Niš, ED Prokuplje, ED Pirot, ED Leskovac and ED Vranje",

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade

26. "Combined Thermal Power Plant Novi Sad engagement effects analysis",

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade

27. "Energy availability of substations in "Zorka Keramika Šabac" enterprise",

Ordered by: Zorka Keramika Šabac

28. "Effects and technical conditions of "Vulić i Vulić" consumer distribution network connection",

Ordered by: Public Utility Elektrosrbija Kraljevo

29. "Short circuit currents calculation in Hydro Power Plant Đerdap 1 and 400 kV Plant Đerdap 1",

Ordered by: Public Utility HPP Đerdap Kladovo

30. "Excitation current and power loss dependence of reactive load level in Thermal Power Plant "Obrenovac" synchronous generators",

Ordered by: Public Utility "Thermal Power Plant Nikola Tesla", Obrenovac

31. "Reactive Power Compensation Influence to Transport System HV Motor Operation in Coal Mining System "TIP" JP RB "Kolubara" - Concept of Reactive Power Compensation in Drobilana PK Tamnava Istočno Polje Drive"

Ordered by: Public Utility RB Kolubara, Mines Baroševac

32. "Possibility of eliminating transformation 110/35 kV in substation 110/35/20 kV Sremska Mitrovica 1 and possibility of supplying potential load in industrial area of Sremska Mitrovica investigation"

Ordered by: Public Utility Elektrovojvodina Novi Sad

33. "Electrical 6-110 kV network long-term development study for distributive area of Šabac"

Ordered by: Public Utility Elektrosrbija Kraljevo

34. "Study of long-term prospective 35-110 kV network development for distributive areas of Niš, Leskovac, Prokuplje, Pirot and Vranje"

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade

35. "Study of long-term prospective 10 kV network development for Niš"

Ordered by: Public Utility Jugoistok Niš

36. "Load flows, voltage conditions and short circuits 6-35 kV network analyses in refinery Pančevo and improvement possibilities analyses"

Ordered by: NIS A.D. Petrol

37. "Study of long-term 10-110 kV networks development for the distribution area of Lazarevac"

Ordered by: Public Utility Elektrosrbija Kraljevo

38. "Making and verification of Serbian power system (with environment) computer dynamic simulation model"

Ordered by: Public Utility "Elektromreža Srbije", Belgrade

39. "Stability study and generators and block-transformer optimal characteristics

and parameter values choice for generator for Thermal Power Plant "Kolubara B" and "Obrenovac B3""

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade

40. "Rationalization of the own electrical energy consumption in Thermal Power Plant "Kostolac A""

Ordered by: Public Utility "Thermal Power Plants and Mines Kostolac", Kostolac

41. "Revision of long-term distribution network development plan up to 2025 in the wider urban area of Public Utility "Elektrodistribucija Beograd""

Ordered by: Public Utility "Elektrodistribucija Beograd", Belgrade

42. "Load and higher harmonic analysis and solution for reactive power compensation for Ski Center Zlatibor"

Ordered by: Public Utility "Skijališta Srbije", Belgrade

43. "Study of long-term prospective 10 kV network development for the area of Pirot"

Ordered by: Public Utility Jugoistok Niš

44. "Analysis of measurement results and compensation effects to reactive power and higher harmonics reduction for Ski Center Zlatibor"

Ordered by: Public Utility "Skijališta Srbije", Belgrade

45. "Rationalization of electrical energy consumption and reactive power compensation in 6 kV network of "Drmno" mine"

Ordered by: Public Utility "Thermal Power Plants and Mines Kostolac", Kostolac

46. "Study of long-term prospective distribution network development for Budva community"

Ordered by: Budva community, Montenegro

47. "General project with pre-feasibility study for supplying electrical network in Park of nature Golija"

Ordered by: Public Utility "Direkcija za puteve, građevinsko zemljište i izgradnju" Ivanjica

Automation and Control Department

UNINTERUPTIBLE POWER SUPPLY SYSTEMS (RECTIFIERS, INVERTERS AND STATIC SWITCHES) IN LAST 5 YEARS

	Reference	Year
1.	Automatic controled rectifier, 3xARI 220-250D, 4xARI 110-500D, 1xARI 24-70, for TPP „Nikola Tesla A"	2005.
2.	Inverter 2x MPI 50-225, 220V, 50kVA, for TPP „Nikola Tesla B1"	2005.
3.	Static switch SP-60-220M, for TPP „Nikola Tesla B1"	2005.
4.	16 digital controllers MRP-196 type, for rectifiers MARIP 350-300 „Minel-Automatika" in Plasmatorch facility, for TPP „Nikola Tesla A"	2005.
5.	Reconstruction of „Energoinvest" rectifiers and and installation of 10 digital controllers DRI05 type, DRI 24-250, DRI 24-600, DRI 48-400, DRI 220-400, for TPP„Nikola Tesla B"	2005.
6.	Automatic controled rectifier, DRI 220-63-1, with battery 300Ah, for „Lafarge BFC" Beočin	2005.
7.	Inverter with static switch MISP 25-220-380, for TPP„Nikola Tesla A1"	2006.
8.	Automatic controled rectifier, 2xDRI 220-70PTM, 1xDRI 220-70PTS, for HPP„Đerdap II"	2006.
9.	Automatic controled rectifier, DRI 220-63-2, with battery 300Ah, for „Lafarge BFC" Beočin	2006.
10.	Reconstruction of two rectifiers ARI -220-315-D, for TPP „Kostolac A"	2006.
11.	Inverter with static switch MISP 25-220-380, for TPP „Nikola Tesla A4"	2007.
12.	Inverter 3xMI 110/220-1500, for EDB Kruševac	2007.
13.	Modular inverter MI 220/220-3500, with static switch SBN-M-220-14, for HPP „Đerdap II"	2007.
14.	Reconstruction of inverter SAPS 220-6300, for HPP „Đerdap II"	2007.
15.	Reconstruction of static switch SPR 220-30, for HPP „Đerdap II"	2007.
16.	Inverter with static switch MISP 25-220-380, for TPP	2007.

	„Nikola Tesla A2"	
17.	Automatic controled rectifier, 3xDRI 220-250, 3xDRI 110-500, for TPP „Nikola Tesla A"	2007.
18.	Automatic controled rectifier DRI24-50, for Belgrade water-works and sewerage corporation	2007.
19.	Inverter with static switch MISP 110-5000-1N, for HPP „Ovčar Banja"	2007.
20.	Inverter with static switch MISP 25-220-380, for TPP „Nikola Tesla A6"	2008.
21.	Inverter 2x MPI 50-225, 220V, 50kVA,for TPP „Kostolac B"	2008.
22.	Static switch SP-60-220M, for TPP„Kostolac B"	2008.
23.	Automatic controled rectifier DRI110-100 with DC switchboard RJS110, for HPP „Ovčar Banja"	2008.
24.	Automatic controled rectifier 2xDRI48-50PTM,for HPP "Međuvršje"	2008.
25.	Reconstruction of rectifiers 2xDRI220-800D, 6xDRI24-800, for TPP „Kostolac B"	2008.
26.	Inverter and static switch 5KVA, for HPP "Međuvršje"	2008.
27.	Inverter and static switch 20KVA, for HPP "Bočac"	2009.
28.	Static switch, for TPP "Kostolac A"	2009.
29.	Automatic controled rectifier, 2xARI 220-70, 2xARI 48-70, for HPP "Bočac"	2009.
30.	Reconstruction of rectifiers 2xARI 220-120, TPP "Kostolac A1"	2009.
31.	Reconstruction of 6 rectifiers with installation of 6 digital controllers, for TPP „Nikola Tesla B"	2009.

AUTOMATIC BUS TRANSFER AND AUTOMATIC SYNCHRONIZING UNITS

1. Automatic High-Speed Busbar Transfer Unit for medium voltage distribution system, installed in 2009 in "Nikola Tesla-A" Thermal Power Plant on Generation Unit No.3.
2. Automatic High-Speed Busbar Transfer Unit for medium voltage distribution system, installed in 2008 in "Nikola Tesla-A" Thermal Power Plant on Generation Unit No.6.
3. Automatic High-Speed Busbar Transfer Unit for medium voltage distribution

system, installed in 2008 in "Kostolac-B" Thermal Power Plant on Generation Unit No.1.

4. Dual-Channel Automatic Generator Synchronizing Unit, installed in 2009 in "Novi Sad" Thermal Power Plant on Generation Units No.1 and No.2.
5. Automatic Generator Synchronizing Unit, installed in 2008 in "Nikola Tesla-A" Thermal Power Plant on Generation Unit No.6.
6. Automatic Generator Synchronizing Unit, installed in 2008 in "Kostolac-B" Thermal Power Plant on Generation Unit No.1.
7. Automatic Generator Synchronizing Unit, installed in 2007 in "Nikola Tesla-A" Thermal Power Plant on Generation Unit No.4.
8. Automatic Generator Synchronizing Unit, installed in 2006 in "Nikola Tesla-A" Thermal Power Plant on Generation Unit No.1.
9. Automatic Generator Synchronizing Unit, installed in 2005 in "Nikola Tesla-A" Thermal Power Plant on Generation Unit No.2.
10. Automatic Generator Synchronizing Unit, installed in 2004 in "Nikola Tesla-A" Thermal Power Plant on Generation Unit No.5.

POWER SUPPLY AND CONTROL SYSTEMS FOR ELECTROSTATIC PRECIPITATORS

The most recent projects (in the last 5 years) are listed below:

1. Power Supply and Control Systems for Electrostatic Precipitators (4 units) for 110MW Generator in TPP „Kostolac A", 2005.
2. Power Supply and Control Systems for Electrostatic Precipitator for 348,5MW Generator B in TPP "Kostolac B", 2005.

3. Power Supply and Control Systems for Electrostatic Precipitators (8 units) for 210MW Generator A1 in TPP "Nikola Tesla A", 2005.
4. Power Supply and Control Systems for Electrostatic Precipitators (4 units) for 110MW Generator A5 in TPP "Kolubara A", 2006.
5. Power Supply and Control Systems for Electrostatic Precipitators (8 units) for 210MW Generator A1 in TPP "Nikola Tesla A", 2006.
6. Power Supply and Control Systems for Electrostatic Precipitators (8 units) for 308MW Generator A4 in TPP "Nikola Tesla A", 2007.
7. Power Supply and Control Systems for Electrostatic Precipitators (8 units) for 110MW Generator A5 in TPP "Kolubara A", 2009.

STATIC EXCITATION SYSTEMS FOR SYNCHRONOUS MACHINES

The most recent projects (in the last 5 years) are listed below:

Legend: DASC – dual automatic channel system
SACS – single automatic channel system

1. DASC excitation system with digital automatic regulator for generator No.5 in TPP „Nikola Tesla A", 308MW, 2004
2. DASC excitation system with digital automatic regulator for generator No.2 in TPP „Nikola Tesla A", 210MW, 2005.
3. Reconstruction of static excitation power stage without regulator and implementation of digital thyristor firing mechanism for generator G2 in TPP „Novi Sad", 190MVA, 2006.
4. DASC excitation system with digital automatic regulator, and data acquisition system for generators No.4 in TPP „Nikola Tesla A", 308MW, 2007.
5. DASC excitation system with digital automatic regulator for generator in HPP „Kokin Brod", 2 x 12.5MVA, 2007.
6. Reserve automatic voltage regulator for generator No.1 in TPP „Nikola Tesla A" - 210MW, 2008.
7. DASC excitation system with digital automatic regulator and data acquisition system for generator No.1 in TPP „Kostolac B", 348.5MW, 2008.
8. Reserve automatic voltage regulator for generator No.2 in TPP „Nikola Tesla A", 210MW, 2009
9. Reconstruction of static excitation system for generator No.1 in TPP „Kostolac A" Implementation of digital automatic regulator and data acquisition system, 110MW, 2009.
10. DASC excitation system with digital automatic regulator and data acquisition system for generator No.5 in TPP „Kolubara", 110MW, 2009.
11. DASC excitation system with digital automatic regulator and data acquisition system for generator in HPP „Potpeć", 3 x 20MVA, 2008/2009.
12. DASC excitation system with digital automatic regulator and data acquisition system for generator No.1 in TPP „Nikola Tesla A", 210MW, 2009.
13. SACS excitation system with digital automatic regulator and electrical breaking for generators in HPP „Medjuvršje", 4 + 6.3 MVA, 2009.
14. DASC excitation system with digital automatic regulator, electrical breaking and data acquisition system for generators in HPP „Bočac", 2 x 65MVA, 2009.

15. SACS excitation system with digital automatic regulator and electrical breaking for generators in HPP „Ovcar Banja", 4 + 6.3 MVA, 2009.
16. DASC excitation system with digital automatic regulator for generator in TPP „Morava", 125MW, 2009.

Electiric Power Facilities Department

Studies:

1. Research study of grounding systems in the 10 kV distributing network of the city of Niš
2. Experimental research of currents and transient overvoltages in distributing networks of 35 kV, 20 kV, 10 kV i 6 kV voltage levels
3. Experimental research of overvoltages during switching operation of vacuum and SF_6 circuit breakers of different manufacturers
4. Analysis of transferred earth potentials in grounding systems of 6 kV and 20 kV networks of surface coal minings of Electrical Power Board of Serbia
5. Analysis of industrial-frequency electric and magnetic fields inside facilities of Electrical Power Board of Serbia
6. Environmental influences of overhead lines from 110 to 400 kV voltage levels and security measures
7. Environmental influences of industrial-frequency electric and magnetic fields of facilities of Electrical Power Board of Serbia

Electrical Measurements Department

I Laboratory for Electrical Insulation testing

Laboratory for Electrical Insulation testing is a division of Laboratory for Calibration and Testing of EEI Nikola Tesla dealing with diagnostic field tests and measurements of high voltage electrical equipment:

- *power transformers* (step-up generator, auxiliary, distribution, interconnection and other power transformers in industry)
- *rotating machines* – turbine- and hydro-generators, high voltage motors
- *HV instrument transformers* (oil-filed and capacitive instrument voltage transformers and current instrument transformers in HV switchyards

Diagnostic field tests and measurements of HV electrical equipment are performed within the Program of preventive testing and control or as part of the complex diagnostic of HV equipment condition.

1. **Power transformers and HV instrument transformers Condition Based Monitoring (CBM)** derived from results of diagnostic field tests and measurements and in close cooperation with **Chemical laboratory for oil and paper insulation testing** has been performed on regular basis for 40 years. During that period a rich data-base of testing results and reports was formed.

   CBM is based of Power Transformers on the following electrical tests on field:
   - measuring of resistance and polarization index of Electrical Insulation System (EIS)
   - EIS dissipation power factor-tan delta and capacitance measurement
   - EIS dissipation power factor-tan delta and capacitance measurement of HV bushings
   - Low Voltage no-load current and power measurement
   - Leakage inductance measurement
   - Winding resistance measurement and OLTC condition testing
   - Mechanical-condition assessment of transformer windings by sweep frequency response analysis (SFRA)
   - Recovery Voltage Measurement with assessment of moisture content in solid insulation

   CBM is based of HV instrument transformers on the following electrical tests on field:
   - measuring of resistance and polarization index of Electrical Insulation System (EIS)
   - EIS dissipation power factor-tan delta and capacitance measurement
   - EIS dissipation power factor-tan delta and capacitance measurement of HV bushings
   - On-line acoustic (ultrasound) partial discharge detection

Electrical tests are performed according to relevant national technical recommendations, IEC and IEEE standards.

Complex Diagnostics Condition Assessment of power and HV instrument transformer is made on the basis of own experience, statistics evaluation of data base in very close cooperation with our *Chemical laboratory for oil and paper insulation testing*, following rules of IEC and IEEE, CIGRE guides, technical brochures for interpretation of test results.

2. **Rotating machines – turbine and hydro-generators and HV motor Condition Based Monitoring (CBM)** has been also performed for over 30

years. A special data base of rotating machinery test results and reports has been formed and is used in condition based assessment.

CBM is based of Rotating Machines on the following diagnostic field tests and measurements:

Stator Winding:

- visual inspection (if possible)
- measuring of resistance and polarization index of Electrical Insulation System (EIS)
- DC HiPot testing and DC leakage current measurement
- Stator winding insulation power factor and tip-up and capacitance measurement
- AC leakage current measurement
- Off-line partial discharge testing
- Stator winding turn-to-turn insulation test (BAKER test)
- AC HiPot overvoltage test
- Winding resistance
- Stator winding RTD/TC insulation and validity test

Stator Core:

- visual inspection (if possible)
- Rated Flux – Loop Flux Stator Core Test
- Low Induction Stator Core Imperfection Test

Rotor Winding:

- visual inspection (if possible)
- Rotor winding Insulation resistance (on stand-still or in rotation)
- Turbine rotor winding impedance (on stand-still or in rotation)
- Salient Pole Winding Resistance and pole-to-pole connection condition assessment
- Turn-to turn turbine rotor insulation condition assessment by Recurrent Surge Generator test (on stand-still or in rotation)

Electrical tests for CBM of rotating machinery are also performed according to relevant national technical recommendations, IEC and IEEE standards.

Customers for services performed under item 1. and 2.are following:

- All thermal and hydro power plants in Serbia and Montenegro
- Several thermal and hydro power plants in Macedonia, Bosnia Herzegovina, Republika Srpska, Slovenia
- Transmission power companies in Serbia and Montenegro
- Distribution companies in Serbia

Railway and other industry facilities in Serbia

II Chemical laboratory for oil and paper insulation testing

3. Power transformers and oil filled instrument transformers Condition Based Monitoring (CBM) derived from oil analysis has been performed on regular basis during last 4 decades.

CBM derived from Oil analysis includes following measurements:

- Dissolved gas analysis (DGA) and free gas analysis according to IEC 60567 and IEC 60599
- Determination of water content in the oil using Karl Fisher according to IEC 60814
- Determination of furan compounds in the oil according to IEC 61198
- Determination of physical, chemical and electrical oil properties according to IEC 60422
- Determination of antioxidants and metal passivators in the oil according to IEC 60666
- Determination of particles in the oil according to IEC 60970 and ISO 4406
- Determination of oil oxidation stability according to IEC 61125
- Determination of corrosive sulphur in the oil according to IEC 62535, DIN 51353 and ASTM 1275
- Determination of aromatic content in the oil according to IEC 60590
- Determination of PCB in insulating oils according IEC 61619

Diagnostics of power transformer condition was drawn on the basis of own experience, statistics evaluation of data base in synergy with results on electrical measurements if performed and available, following rules of IEC and IEEE, CIGRE guides and technical brochures for interpretation of test results.

2. Other tests on oil and paper insulation, laboratory simulations for optimization of on-site processes have been performed for

- Testing of new unused insulating oils according to IEC 60296 spec. for all customers mentioned above (Production, transmission and distribution and industry in Serbia and neighboring countries in region)
- Determination of paper insulation water content and degree of polymerization (Dp) and evaluation of paper insulation applicability in power transformers.
- Laboratory simulation of oil reclamation for optimization of on-site process, determination of optimum process parameters: temperature, number of cycles, type and mass of sorbent needed, expected oil results after reclamation, quantity of antioxidant needed for re-inhibition.
- Laboratory simulation of addition of metal passivators in power transformers, determination of optimum metal passivator quantity needed for complete inhibition of copper sulphide formation, determination of optimum process parameters for addition on-site: pressure, temperature, number of hours for oil circulation, followed by recommendations for further monitoring of passivated transformers in service.

Customers for services performed under item 1. and 2.are following:

- All thermal and hydro power plants in Serbia and Montenegro
- Transmission system in Serbia and Montenegro, Republika Srpska

- Distribution companies in Serbia
- Industry and railway in Serbia, Montenegro, Macedonia

3. Development of new and improvement of existing technologies for transformer insulation revitalization on-site: drying and flushing of solid insulation with oil reconditioning and reclamation: know-how, supervision of the process on-site and control measurements, were performed for following customers:

- Serbia Transmission company (EMS, transformer - TS Smederevo 3 T2), during 2006
- Hydropower plant In Montenegro (HE Perućica - GSU 3 and GSU 4), during 2007
- Transmission company in Montenegro (Elektroprenos Podgorica, TS Danilovgrad T1), during 2008
- Know-how and supervision of process of metal passivator addition on-site done for: Hydropower plant HE Perućica, EMS, HE Đerdap I.

For certain transformer construction, tanks that can not withstand vacuum new technology for drying of solid insulation was developed, using two working fluids at higher temperatures. Technology was developed in INT chemical laboratory, tested on lab scale and applied on-site in Hydropower plant HE Perućica on GSU 3 and GSU 4. Similar technology was applied on transformer Danilovgrad T1 in Transmission company of Montenegro.

4. Activities in development of new and revision of existing test methods and IEC standards: inter-laboratory test - Round Robin Tests within IEC TC 10 and CIGRE WG: IEC TC 10 WG17, MT 24, WG 35, CIGRE TF01 RRT, CIGRE A2.32.TF02 RRT, CIGRE A2.32.TF03 RRT, CIGRE D1.01.17 RRT from 2004 – 2009

5. Research project for AREVA T&D: MOISTURE DISTRIBUTION AND AGEING OF VEGETABLE ESTER OILS IN TRANSFORMER INSULATION, 2009.

III Testing of product electrotechnic characteristics

In great number of cases testings are performed for control of **declared electical characteristics** of domestic and imported products, for different customers.

- Electric-isolation product testings;

- Electric lamp testings;

- Electric complex testings;

- Electric equipment and tools testings.

Another group of testings are performed to determine **electrical resistance of paths for static electricity leading**, in buildings where protection from static electricity is obligatory.

Customers where above mentioned testings were performed are:

- Military industry,
- Pharmacy company "Galenika",
- "Graditelj"-Novi Sad,
- ''Jugoinspekt"- Beograd,
- "Aerodrom"- Beograd,
- "Klinicki centar"- Beograd,
- "Industrija obuce Beograd "- Beograd,
- "TENT"- Obrenovac.

IV Other projects and studies

(1) Project No. 251034 financed by Ministry of Science and Environmental Protection "Introduction of Energy Management System and Application of Energy Efficiency Measures in Paper Industry", User: Paper mill "Božo Tomić", Čačak, Serbia, 2005.
(2) Project No. 251035 financed by Ministry of Science and Environmental Protection "Rationalisation of energy efficiency in water supply pump stations supplied by variable speed electrical drives", User: Belgrade Municipal Water Utilities, Serbia, 2005.-2006.
(3) General design of motor soft starter for main turbine. Investor: Oil Rafinery Pančevo, Serbia, 2006.
(4) Conceptual design "Introduction of frequency converters for 6kV electrical drives", Investor: PE Coal Mines Kolubara, Serbia, 2006.
(5) Project No. 222001 financed by Ministry of Science and Environmental Protection "Development of measurement and information system for supervising and analysis of utility power transformer stations",
(6) Project „Medium voltage distribution network automation" in cooperation with Radius South East Europe. Project started from 2006. and include several distribution companies (PD Jugoistok Niš, PD Elektrosrbija Kraljevo, PD Centar Kragujevac) and theirs subsidiaries (distribution companies in: Niš, Pirot, Prokuplje, Leskovac, Aleksinac, Kraljevo, Kruševac, Kragujevac, Požarevac, Smederevo). Currently active is a large project for PD EDB - Belgrade Electrical Utility Company (about 100 locations in Belgrade zone). At every location project activities include Design concept report, General

telecommunication project, equipment purchase, installation and supervising, Final project and training of local stuff.

(7) Study: "Measurements and power quality analysis of the power supply for electrostatic precipitator". Investor: ZVVS Czech Republic, EU. Performed at Thermal Power Plant Kostolac A, Kostolac, Serbia, 2007.

(8) Study: "Measurements and power quality analysis of supply transformer for electrostatic percipitator". Investor: Electric Power Industry of Serbia. Performed at Thermal Power Plant "Nikola Tesla", Obrenovac, Serbia, 2007.

(9) Study No. 222007 financed by Ministry of Science and Environmental Protection under the National energy efficiency programme "Contemporary Methods and Devices for Monitoring and Diagnosis of power and measurement transformers".

(10) Project No. TP-6615B financed by Ministry of Science and Environmental Protection "Development and application of the contemporary diagnosis methods in EPS' power system objects".

(11) Project No. TP-6604B financed by Ministry of Science and Environmental Protection "Revitalization of the paper-oil isolation system of the power transformers in exploatation".

(12) Project No. 223010 financed by Ministry of Science and Environmental Protection "Application of Contemporary Methods and Devices for Analisys and Control of Power Quality According to Approved EU Standards".

(13) Project No. 223003 financed by Ministry of Science and Environmental Protection "Metrological Supervision of Energy Meters in Power Distribution Plants".

(14) Acredited Laboratory Power Quality tests and analysis for several customers and projects at Electric Power Industry of Serbia, Oil Rafinery Pančevo, Lafarge Cement Industry.

(15) General project of reactive power compensation at Belgrade High School. Project design, power quality measurements, equipment purchase and installation. Serbia, 2007.

(16) Energy efficiency project in Guča Foundry "Preliminary audit" in cooperation with Faculty of Mechanical Engineering (Serbian Industrial Energy Efficiency Network – MEEIS). Serbia, 2007.

(17) Project of reactive power compensation at 0,4kV level in Pančevo Oil Rafinery power system: Detail power quality measurements and analysis, preliminary design, equipment specification. Serbia, 2008.

(18) Inovation project No. 451-01-00069/2008-01/110 in cooperation with Faculty of Electrical Engineering University of Belgrade, partialy finaced by Ministry of Science, "Development of multichannel digital system for power quality parameters acquisition at utility power stations".

(19) Project No. 17029 financed by Ministry of Science "Development of integrated compex diagnosis of power and measurement transformers conditions".

(20) Project No. 17030 financed by Ministry of Science "Improvement of insulation system condition diagnosis of turbo generators by development of partial dischage OFF-LINE and ON-LINE measurements".

(21) Project for Thermal Power Plant "Nikola Tesla" B "Development of monitoring system for power transformer at block B2". Project include

research, design, development, installation of the equipment, software for data acqusition and database storage. System is consisted of thermal monitorign and protection and on-line analysis of gases in transformer oil. Serbia, 2009.-2010.

(22) Projects and realisation of temperature monitoring system for hydrogenerator, stator and remote temperature measurement of rotor poles of hydro-generators. HE Djerdap II, 2008.

(23) Project for practical realisation of hot-box detector for temperature measurement of bearings of railway cars.

(24) Devices for instrument transformers accuracy testing .

(25) Belt conveyor scales for coal measuring developed for: Power plant "Nikola Tesla B" Obrenovac.

(26) Calibrator for amplitude error and phase displacement for instrument transformers, Bureau for measure and precious metals.

(27) Measuring instruments calibration in Acredited laboratory for calibration, for different customers.

(28) Instrument transformers accuracy testing on site and in laboratory, for different customers.

(29) Study for EPS: Magnetic Monitoring of Electrical Rotational Machines in EPS Power Plants, (Turbogenerators, Hydrogenerators and High Voltage Squirel Cage Induction Motors), 2009.