

1. "Analysis of the expected impact of wind farms "Ram", "Danube 1", "Danube 2" and "Danube 3" to the distribution network"

Ordered by: MK-Fintel Wind, Belgrade

Project Manager: Saša Minić, MSc.

Associates: Sanja Ivković, MSc.  
Jelena Perić, MSc.

The subject of this study was to assess the impact of wind farms "Ram", "Danube 1", "Danube 2" and "Danube 3" to the distribution network in the region of Veliko Gradište. The analysis was based on the results of testing wind turbine V112-3.0 MW supplied by the manufacturer, data of distribution network functioning for the period 2011-2012, as well as measurements of wind speed at two locations near future wind farms for the period 2005-2007 which were base for assessment of future output of individual wind turbines. Analysis was made for three proposed variants of connection. For each variant of connection following analysis of connection possibilities were made:

- Analysis in terms of voltage variations in transient periods (for each wind farm individually and collectively for all of them);
- Analysis in terms of increasing the content of current harmonics in the power distribution network;
- Analysis in terms of noise caused by long duration flickers;
- Analysis of the individual and collective impact of wind farms on network functioning in stationary modes (maximum and minimum) in terms of voltage fluctuations and meeting security criteria "n-1" in 110/35 kV transformation;
- Analysis of impact of wind farms on the short circuit power increment in substation near wind farm connection points.

Size of Project: 39 pages

Finished in: 2013.

2. "Load flow, reactive power compensation and subtransient short circuit calculation within the project of reconnecting 6 kV power supply from existing substation 35/6 kV to new 220/6 kV substation of Pančevo Refinery"

Ordered by: NIS Petrol, Pančevo Refinery, "Termoelektro-Projekt", Belgrade

Project Manager: Dragan Dabić, MSc.

Associates: Miloje Kostić, PhD.  
Branka Kostić, MSc.  
Saša Minić, MSc.  
Nikola Georgijević, MSc.  
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Nikola Sučević, MSc.

The subject of this study was computation of the short-circuit and ground fault for characteristic points of the existing 6 kV network, in terms of new supply conditions, the short-circuit parameters of 220 kV network and projected configuration of the power system, which have been subject of modernization. Check of existing switches and current measurement transformers was performed for short-circuit current value that is the most critical for the referenced element. The load flow analysis was considered for several network switching states, for the initial and the final configuration of 6 kV network and graphics for optimum switching state of each network configuration have been presented. Optimal reactive power compensation for proposed 6 kV network configuration was proposed.

Size of Project: 61 pages

Finished in: 2013.

3. "Analysis of possibility of small hydro power plant "Bučevka" grid integration",

Ordered by: "Elektromonter" d.o.o, Požega

Project Manager: Saša Minić, MSc.

The subject of this report is to analyze the possibilities and define maximum power generation of HPP "Bučevka" for grid integration from the perspective of voltage change range at the connection point in the transient period and voltage criteria at stationary state in case of maximal and minimal network load. Potential HPP is situated in the area supplied by 35/10 kV substation Sastavci. Conditions that define the connection of several small hydro power plants at 35 kV voltage level around 35/10 kV substation Sastavci have already been issued. The total installed power of these power plants goes beyond specified load power. This situation in the network causes an increase of voltage in the area of the power substation Sastavci which has been analyzed in this study. Analysis of impact on the power distribution system functioning have

been made for one connection point with respected impact of the different involvement of power plant with different power factors.

Size of Project: 11 pages

Finished in: 2013.

4. "Analysis of possibility of small hydro power plant "Brusnik" grid integration",

Ordered by: "Mimar Energy" d.o.o, Čačak

Project Manager: Saša Minić, MSc.

The subject of this report was to analyze the possibilities for grid integration of HPP "Brusnik" from the perspective of voltage change range at the connection point in the transient period and voltage criteria at stationary state in case of maximal and minimal network load. Expected powers of generators, which should be installed in the HPP Brusnik, are  $2 \times 277 + 100$  kW. These output powers have been determined based on the turbines' powers and power efficiency of generators. With respect to the maximum active engagement that designed generators allow, in terms of meeting the defined technical criteria, different modes of aggregates reactive engagement have been examined in the study. Considering the specificities of consumption, special attention has been devoted to the determination of the maximum load in the distribution network. In a mode of minimal load and maximal power plant engagement, the total installed power of power plant goes beyond specified load power. This situation causes an increase of voltage in the power plant's connection point.

Size of Project: 16 pages

Finished in: 2013.

5. "Analysis of the effects of the implementation of pilot project "Public Utility "Elektro distribucija Beograd" medium voltage distribution network automation",

Ordered by: Public Utility "Elektro distribucija Beograd", Belgrade

Project Manager: Nada Vrcelj, MSc.

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Aleksandar Ivanov, MSc.

Analysis of the effects of automation in the 10 kV voltage level in Public Utility "Elektro distribucija Beograd" was carried out by monitoring the parameters of reliability of customer supply and quality of electric energy delivery during two periods. Period of several years before the applying of automation, ending with 2010 has been observed at first. Then, analyses of most part of period during implementation of re-closers in the remote control, until December of 2012, with special emphasis on a trial six-month period, have been done. Analysis results are presented by multiple categories, according to the type of available data. The first two categories have been related to the calculation of undelivered electricity for re-closers that it has been possible to reconstruct the past events or to estimate this parameter with relatively high accuracy. Automated and not automated parts of network have been analyzed separately. Indicators that can be calculated from the data contained in the dispatcher diaries have been represented within the other two categories. In this case, data processing and data itself were sorted geographically. The fifth category provides the results of the cost analysis in the cycle: the moment of the failure - the determination of the fault's location and exclusion of the part of the network for repair - repair. The results of the interviews of selected major consumers have been given in the sixth category. Seventh category describes the influence of automation to reduction of the peak power in order not to exceed allowable value, which is subject of penalty paying.

Size of Project: 100 pages

Finished in: 2013.

6. "Possibility of connection of HPP Zapeće and HPP Ilomska to upgraded distribution network of Elektrokrajina Banja Luka",

Ordered by: "Interenergo" d.o.o., Ljubljana  
Project Manager: Saša Minić, MSc.  
Associates: Maja Marković, MSc.  
Jelena Perić, MSc.  
Sanja Ivković, MSc.

The subject of this study has been to analyze the possibilities of connecting the new HPP Zapeće and Ilomska on the distribution network, taking into account the new circumstances created by the connection of HPP Novakovići and potential reinforcement of the distribution network. This reinforcement involves possibility of forming a supply point on 35 kV voltage level in the substation 110/20 kV Kotor Varoš, making the necessary reconstructions and the adjustments. It has been shown that analyzed HPP can be connected to the chosen point of connection only if there is a protocol according to which generators connect to the grid with permissible power of connection. The analyses have shown that all three HPP could connect to the reinforced distribution network from the perspective of voltage change at stationary state. This requires that the voltage value, in substation 110/35/20 kV maintains in a predefined range. At the same time, transmission ratio of transformer 35/20 kV in substation 35/20 kV should be set to the nominal value. The critical voltage in 35 kV network is on the 35 kV side HPP Ilomska. Even in the critical modes, with minimum load and maximum engagement of HPP, voltage should remain within the permissible range.

Size of Project: 18 pages

Finished in: 2013.

7. "Network analysis of Kruševac branch of Public Utility "Elektrosrbija" Kraljevo with 110/10 kV substation Kruševac 3"

Ordered by: Public Utility "Elektrosrbija", Kraljevo  
Project Manager: Maja Marković, MSc.

The subject of this report is a comparative analysis of network development in the area of Kruševac with and without upgrading Kruševac 3 substation from 35/10 kV transformation to 110/10 kV transformation. The existing network does not have major problems in the normal operation mode, but from the perspective of security of supply does not meet the criteria. Therefore, primary task of this report has been to find a way to discharge the TS Kruševac 4 and redistribute that load on the surrounding or new substations on 110 kV voltage level. Investments required for the implementation of all the proposed solutions have been analyzed. Based on techno-economic analysis, a conclusion has been given, regarding to the selection of the optimal solutions.

Size of Project: 6 pages

Finished in: 2013.

8. "Study of long-term prospective 35-110 kV network development in the area of Public Utility PD "Centar" d.o.o. Kragujevac",

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade  
Project Manager: Gordana Radović, MSc.  
Associates: Nikola Šušnica, MSc.  
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Aleksandar Ivanov, MSc.

This study is result from the need to consider the development of 110 kV and 35 kV network on a full area of the ED Centar in the future. This 6013 km<sup>2</sup> wide area, covering three regions in the central Serbia, has ~285 000 electrical energy customers (~590 000 residents) with ~2500 GWh annual consumption.

The study covers the period up to the 2025. At the same time the new circumstances in relation to price of network elements, load disposition, future solutions regarding to development of the transmission network in Serbia, as well as significantly better substrate in terms of consumption data, network measurements and failures have been taken into account.

The study includes analyses of energy consumption development for the period up to the year of 2012, as well as load and energy consumption forecast until the year of 2025. As preparation for study, all points in 10-110 kV network are tracked and transferred to GIS environment, based on previously digitalized geo-referenced maps. Detailed analyses of 110 kV, 35 kV and 10 kV networks present condition (including physical state of networks, load of elements, voltage conditions and losses) have been accomplished.

Based on these analyses, results of load forecasting, techno-economical analyses and comparison of possible development variants, the most prosperous solution of 35-110 kV distributive network further development in the considered area for the period up to the year of 2030 has been suggested, taking into account 10 kV network capabilities. Existing and future distributed production of electricity has been taken into account in the analysis and planning of development. Effects of its connection to the network for maximum and minimum network load have been analyzed for all network development phases.

Size of Project: 419 pages

Finished in: 2013.

9. "Calculation of relay protection settings within the project of reconnecting 6 kV power supply from existing 35/6 kV/kV substation to new 220/6 kV/kV substation of Pančevo Oil Refinery",

Ordered by: NIS Petrol, Pančevo Oil Refinery "Termoelektro-Projekt" d.o.o, Belgrade Project Manager: Dragan Dabić, MSc.

Associates: Branka Kostić, MSc.

Igor Belić, MSc.

Saša Minić, MSc.

Nikola Sučević, MSc.

This study is a continuation of the study "Calculation of relay protection settings within the project of reconnecting 6 kV power supply from existing 35/6 kV/kV substation to the new 220/6 kV/kV substation of Pančevo Oil Refinery" which was done during 2012. A set of protective functions by positions of switchgear is defined. Calculations are made for settings of relay protection of generator (6 kV, 14.125 MVA), 6/0.4 kV/kV transformers, 6 kV motors, 6 kV cables, 6 kV measuring units and 6 kV capacitors. The new adjustments have been made on those positions where changes of current settings are necessary, in order to ensure protection coordination and selectivity. Calculation methods, for each protective function, are explained in details. Proposal for the introduction of a new relay protection and their setting is also given. Changes of current transformers on some feeders have been proposed, too. After the proposed adjustments, thermal endurance of cables was checked.

Size of Project: 59 pages

Finished in: 2013.

10. "Rationalization of electrical energy consumption and reactive power compensation in coal mine "Kolubara"", 1<sup>st</sup> phase, Open-Pit Mine Tamnava",

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade

Project Manager: Miloje Kostić, PhD.

Associate: Nikola Georgijević, MSc.

This project includes two parts with 11 chapters, which reflect its content and concept.

PART I: Analysis of load and power losses in engines and the network of Open-Pit Mine Tamnava

- Introduction;
- Power supply, consumption of electricity and medium voltage network of OPM Tamnava;
- Analysis of electricity consumption, active and reactive load of 110/35 kV substation Jabučje;
- Analysis of electricity consumption, active and reactive load of 110/35 kV substation Vreoci;
- Analysis of the results of load measurements and higher harmonics of voltage and current in the network;
- Calculations and analysis of load of engines connected to 0.4 kV and 0.6 kV network;
- Calculation and analysis of power losses and voltage drops in 6 kV, 20 kV and 35 kV network;

PART II: Preliminary Design of reactive power compensation in the network of Open-Pit Mine Tamnava

- Global analysis and determination of the required capacity for reactive power compensation in the network of OPM Tamnava;
- Dimensioning of individual reactive power compensation in the OPM Tamnava;
- Inrush currents of capacitors connected to 6 kV network and dimensioning inrush current reactors;
- Selection of structure and sizing of capacitors for mixed compensation in OPM Tamnava;

The main conclusion of this study is that installation of capacitor banks and the usual implementation of reactive power compensation is not possible due to high harmonic distortion of voltage and current in the

considered network, because it would lead to additional distortions and thus the capacitors' breakdown. The reason for this is the dominant share of frequency regulated motors (FRM) in the secondary network of transformer T3 in 110/35 kV substation Jabučje.

A detailed calculation and analysis of the considered variants of reactive power compensation in this network suggested installing a filter section of capacitors in the 35 kV and 20 kV networks. Since this is a relatively expensive solution, a variant based on our solutions - patent "A method for forming anti-resonant filters in medium voltage electrical networks" and our technical solution "Method for preventing occurrence of resonance in networks with capacitors on the secondary side of the transformer HV(MV1)/MV", is discussed and developed.

Size of Project: 299 pages

Finished in: 2013.

11. "Analysis of power quality and voltage changes due to connection of small HPP Velež to the network",

Ordered by: PE "EPS", Subsidiary "Elektrosrbija" d.o.o. Kraljevo, "Univers" d.o.o, Raška

Project Manager: Branka Kostić MSc.

Associate: Saša Minić, MSc.

The subject of this report is to analyze the harmonics that are injected into the distribution system from small hydropower plant "Velež", located near Jošanička Banja, and an analysis of changes in voltage when plant is connecting to the distribution network.

By comparing the results of measuring current's harmonics and limits of these currents on the basis of certain short-circuit power at the connection point it can be concluded that the values of current harmonics is significantly less than the prescribed limit values for all higher-order harmonics and all the analyzed situations. Therefore, the situation, from the aspect of power quality with regard to the level of harmonics, is satisfactory. Besides the values of the current's harmonics, values of voltage's harmonics have been analyzed. It has been established that the change in voltage's harmonics is within the limits determined in "Rules of Procedure of the distribution system".

The measurements of voltage indicated the significant variations in the transient voltage during connecting and disconnecting of the generator, or during a change in the generator's engagement. Part of the voltage's change is the result of the load's variations in the network and the voltage's variations in the connection point, because even in a mode of relatively constant plant's power, or mode when it isn't on the network voltage's variations (on average, in the range of 0.5% in a four seconds) has been observed.

Analyzed measurements have showed that generators which power is less than 360 kVA can be connected to the distribution network with no improper influence on the transient voltage's change. As for the value of the voltage in the stationary mode, the measurement results indicate that a problem exists even without the power plant engagement.

Size of Project: 29 pages

Finished in: 2013.

12. "Analysis of power quality and voltage changes due to connection of small HPP Kaludra to the network",

Ordered by: PE "EPS", Subsidiary "Elektrosrbija" d.o.o. Kraljevo, "Studentica-elektro" d.o.o, Ušće

Project Manager: Branka Kostić MSc.

Associate: Saša Minić, MSc.

The subject of this report is to analyze the harmonics that are injected into the distribution system from small hydropower plant "Kaludra", located near Studenica, and an analysis of changes in voltage when plant is connecting to the distribution network.

By comparing the results of measuring current's harmonics and limits of these currents on the basis of certain short-circuit power at the connection point it can be concluded that the values of current harmonics is significantly less than the prescribed limit values for all higher-order harmonics and all the analyzed situations. Therefore, the situation, from the aspect of power quality with regard to the level of harmonics, is satisfactory. Besides the values of the current's harmonics, values of voltage's harmonics have been analyzed. It has been established that the change in voltage's harmonics is within the limits determined in "Rules of Procedure of the distribution system".

The measurements of voltage indicated the significant variations in the transient voltage during connecting and disconnecting of the generator, or during a change in the generator's engagement. Part of the voltage's change is the result of the load's variations in the network and the voltage's variations in the connection point, because even in a mode of relatively constant plant's power, or mode when it isn't on the network voltage's variations (on average, in the range of 0.8% in a four seconds) has been observed.

The voltage's changes, which are the consequence of the load's variations in the network and the voltage's variations in the connection point, are not considered. Even then changes of the transient voltage are bigger than critical 200 V (2%) in a mode when the power's change is bigger than provisionally approved value. In the mode when engagement of the power plant changes from 300 kW to 360 kW at connection and disconnection, measured voltage's changes are in the range of 2.7 to 4.9 %. When engagement of the power plant changes from 560 kW to 580 kW at connection and disconnection, measured voltage's changes are in the range of 6.7-7.9%. Smaller voltage changes are the result of power plant's engagement in under-excited mode with very low power factor ( $\leq 0.7$ ). This is the only way to influence to the small variations in transient voltage if generator's power is greater than the value specified in "Decision on the approval of a temporary connection MHP Kaludra". Maximum of HPP engagement is calculated in order to keep voltage's changes less than the prescribed 2%. In that case, power plant operates deeply into under-excited mode. This situation is unfavorable for the network's operation in a steady state with maximum load. Voltage conditions are actually worsened in this mode of operation and power losses are increased. As for the value of the voltage in the stationary mode, the measurement results indicate that a problem exists even without the power plant engagement.

Size of Project: 26 pages

Finished in: 2013.

13. "Analysis of possibility of small hydro power plants Murino and Dosova Rijeka connection to 35 kV line Andrijevića - Plav",

Ordered by: "Elektrotehna" d.o.o., Berane

Project Manager: Milan Ivanović, MSc.

Associate: Saša Minić, MSc.

In this study, the possibilities of connecting the small hydropower plants Murino and Dosova reka at 35 kV cable of TS 110/35 kV Andrijevića - TS 35/10 kV Plav have been analyzed. Maximal power of the power plants is analyzed, considering such aspects as: allowed voltage changes in the transitional regime, allowed voltage in steady state, maximum and minimum load of the existing distribution network. Proposition of feeder size is based on the results of cost-effectiveness analysis of power transmission. Influence of power plants to the distribution system for the proposed method of connection has been analyzed. Investment for suggested variants of connection has been roughly estimated.

Size of Project: 22 pages

Finished in: 2013.

14. "System parameters of voltage and frequency regulation in power plants of Electric Power Industry of Serbia",

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade

Project Manager: Dušan Arnautović, PhD, Saša Minić, MSc.

Associates: Dragan Popović, PhD.

Milan Ivanović, MSc.

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Nikola Georgijević, MSc.

Slavko Veinović, MSc.

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Slobodan Bogdanović, MSc.

Dane Džepčeski, MSc.

Jelena Pavlović, MSc.

The main objective of this study is to carry out the appropriate checking, recording, testing, adjustment and analysis of relevant parameters of voltage regulation and turbine control systems of generators in all power plants, in order to improve primary voltage control and primary, secondary and tertiary frequency control. The ultimate goals of this study have been: (1) to improve the quality of listed types of regulation; (2) to analyze possibility of harmonization with the existing valid regulations; (3) to provide reserve in order to perform the primary, secondary and tertiary frequency control and (4) to provide capacities for the production and absorption of reactive power in order to perform the primary voltage regulation. The study exposed relevant methodological and practical aspects of the analysis of both static and dynamic conditions, including a methodology and appropriate computer programs for a more detailed analysis of static and dynamic conditions of power system, and its interconnections. Results and comments for the analysis related to the primary control of frequency and voltages, both for case of isolated operation and for interconnection with their environment, have been presented.

Size of Project: 197 pages

Finished in: 2013.

15. "Study of prospective long-term development of 110 kV and 35 kV electrical network in the area of Elektrosrbija d.o.o. Kraljevo"

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade

Project Manager: Ana Šaranović, MSc.

Associates: Maja Marković, MSc.

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Tijana Janjić, MSc.

Saša Minić, MSc.

The main goal of this study is to consider the development of 110 kV and 35 kV in the whole area, which is supplied by electricity from distribution system operator "Elektrosrbija" Kraljevo for period of the next 20 years (until the 2030). This 25211 km<sup>2</sup> wide area, covering 12 regions in the central, west and southwest Serbia, has ~900 000 electrical energy customers with ≈ 6300 GWh annual consumption. This area is supplied by 57 substations 110/X kV, 226 substations 35/10 kV and almost 12600 substations X/0.4 kV.

The study covers the period up to the 2030. The new circumstances in relation to price of network elements, load disposition, future solutions regarding to development of the transmission network in Serbia, as well as significantly better substrate in terms of consumption data, network measurements and failures have been taken into account.

The study includes analyses of energy consumption development for the period up to the year of 2012, as well as load and energy consumption forecast until the year of 2030. As preparation for study, all points in 6-110 kV network are tracked using GPS devices and transferred to GIS environment, based on previously digitalized georeferenced maps. Detailed analyses of 110 kV, 35 kV and 10 kV networks present condition (including physical state of networks, load of elements, voltage conditions and losses) have been accomplished.

The methodology used in the preparation of forecasts of electricity demand has been described in the study. Within certain branches individual plants were treated separately. For all branches, or units that have been treated within the forecast, there were two versions of forecasts of electricity demand, or power - lower and higher version, in order to include a pessimistic and an optimistic view of the future development in network development plan.

The analysis of potential directions of network's development, where so called target networks with modeled loads from 2030 based on higher forecasts have been formed, has also been presented in the study. The necessity for including some new facilities 110/X and 35/X kV into operation, and the need for change of installed capacity in existing facilities have been analyzed. Within the formation of target networks the necessary reinforcements in the medium voltage grid, primarily due to the need to eliminate the problem of bad voltage conditions in some parts of rural networks, and the necessity to form a functional inter-connective lines and functional loops 10 (20) kV, which are significant from the aspect of security of supply, have been discussed. The detailed elaboration of the proposed, alternative solutions of network development, for each branch has been exposed.

Based on these analyses, results of load forecasting, techno-economical analyses and comparison of possible development variants, the most prosperous solution of distributive network further development in the considered area for the period up to the year of 2030 has been suggested.

Size of Project: I part - 521 pages, II part - 646 pages

Finished in: 2013.

16. "Analysis of the effects of a potential operation of TS 400/110 kV Beograd 20 in the period 2009-2013"

Ordered by: Public Utility "Elektromreža Srbije ", Beograd

Project Manager: Saša Minić, MSc.

The object of this study is to analyze the effect of potential entry of substation 400/110 kV Belgrade into the operation on losses in the transmission network during the period 2009-2013. The basic assumptions for the model's formation, based on knowledge of the transmission network's functioning, have been defined at first. Afterwards, the part of the transmission network that is relevant for the analysis has been isolated.

Calculations that needed to be realized in order to evaluate adequately the impact of substation 400/110 kV Belgrade 20 on network losses reduction have been defined on the basis of the available data. Results of the calculations performed based on established methodology have been given. The effects of reducing the energy losses and costs to cover the losses are presented for three different scenarios:

- Scenario 1 - for period from October 2010;
- Scenario 2 - for period from July 2010;
- Scenario 3 - for period from September 2009;

Size of Project: 13 pages

Finished in: 2013.

17. "Feasibility study for monitoring of energy balance of Energy Block",

Ordered by: "Termoenergo inženjering" d.o.o. Belgrade, NIS a.d Novi Sad

Project Manager: Aleksandar Nikolić, PhD.

Associates: Radoslav Antić, MSc.  
Gordana Radović, MSc.  
Nada Vrcelj, MSc.  
Tijana Janjić, MSc.  
Saša Minić, MSc.

The object of this study is the monitoring of energy balance, i.e. tracking of all inputs and outputs of energy within Energy Block of NIS company. Measuring points (signals that are important for buying, selling and consumption of electrical energy) have been specified within a given project. Equipment that needs to be installed and the scope of required works have, also, been specified in the report.

Size of Project: 50 pages

Finished in: 2013.

18. "Analysis of protection systems in TPP Nikola Tesla A and B and guidelines for their reconstruction",

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade

Project Manager: Dragan Dabić, MSc.

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Dušan Jačić, MSc.  
Tomislav Rajić, MSc.  
Miljana Zindović, MSc.  
Goran Đukić, MSc.  
Pavle Krička, MSc.  
Marko Gostović, MSc.

The main subject of study is analysis of relay protection systems at all voltage levels that exist within TPP Nikola Tesla A and B (further TENT A and TENT B). All the elements in these power plants have been modeled down to the main fuse at the 0.4 kV side of the transformers 6/0,4 kV/kV in TENT A and 6,6/0,4 kV/kV in TENT B. Serbian transmission network together with networks in the region, which were relevant for calculation of short-circuit currents, were also modeled. An analysis of the protection system selectivity for pre-defined critical topology of the transmission network and power plants have been done based on the established model. Analysis was performed using the software package CAPE, manufactured by Electrocon International Incorporated. Change of the parameters and protection settings in the places, where they were not satisfactory set, has been proposed. In addition, the activation of additional protective functions, in places where it was needed, has been suggested. Finally, information about protective devices condition (age) and their reliability as well as their capabilities in terms of additional security features, the necessity and the method for future possible reconstruction of the protection systems have been pointed out.

Size of Project: 599 pages

Finished in: 2013.

19. "Guidelines for the preparation of local development plans in energy sector" as part of project „Norwegian assistance to the energy policy of the Republic of Serbia in the field of energy planning",

Ordered by: Ministry of Energy, Development and Environmental Protection

Project Manager: Saša Minić, MSc.

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Activities in this phase of the project, funded by the donations from the Norwegian Ministry of Foreign Affairs, can be divided into three phases:

- preparation of methodology and creation of Guidelines for preparation of local development plans in the energy sector, which, in fact, is this material;
- creation of a database and information system based on it as a tool for the creation of local development plans in the energy sector;
- preparation of development plans in the energy sector for four selected underdeveloped municipalities in Serbia, in order to demonstrate the functionality of the methodology outlined in this Guidelines, as well as creation of a database and information system that are the foundation and tool for the application of this methodology.

This part of project related to the first phase. Energy planning is a procedure used to determine the aims of short- and long-term energy policy. Future actions, activities, resources, and time limits that should enable the achievement of set goals must be defined in this planning. The methodology for the plan's formation has been shown in this guide. An analysis of the legal framework for energy planning at the local level has been given at first. The possible strategic goals of energy planning are presented. The importance of forming a database, producing energy balances, and making energy efficiency projects as a basis for the development of local energy plans has, also been emphasized. The method for systematization and data processing on individual energy sub-sectors has been given in this guide.

Design of future database and web-oriented application for the preparation of local development plans in energy sector is presented in separate document.

Size of Project: 83 pages (Guidelines) + 39 pages (Design of database and web-oriented application)

Finished in: 2013.

20. "Analysis of possibility of solar power plant "Novi Milanovac" grid integration",

Ordered by: "ML System" d.o.o.

Project Manager: Saša Minić, MSc.

The subject of this report is to analyze the possibilities and define maximum power generation of SPP "Novi Milanovac" for grid integration from the perspective of voltage change range at the connection point in the transient period and voltage criteria at stationary state in case of maximal and minimal network load. Four possibilities of the new solar power plant connecting to 10 kV and 35 kV distribution network were analyzed in this study. Installed power of new solar power plant goes beyond load of connection lines. This situation in the network causes an increase of voltage in the area of solar power plant. For all four analyzed variants of connecting capacity of the relevant network 10 or 35 kV is satisfactory. Analysis, however, showed that, from the point of maximum permissible voltage change in the transient and steady state, the connection of predicted 3x320 kVA inverters is not possible in two of four connection's variants. In the mode of maximal power of solar power plant and minimal network's load, voltages have been significantly above the allowed values in two of four connection variants. All analyzes have been carried out for different levels of solar power plant engagement, in terms of delivered reactive power. Analyses showed that the solution with connection to 35 kV line has been significantly "more stable", in terms of voltage variation, then the solutions with connecting to 10 kV network, and it is recommended for implementation.

Size of Project: 14 pages

Finished in: 2013.

21. "Rationalization of electrical energy consumption and reactive power compensation in coal mine Kolubara", 2<sup>nd</sup> phase, areas "D" and "B",

Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade

Project Manager: Miloje Kostić, PhD.

Associate: Nikola Georgijević, MSc.

This project includes two parts with 11 chapters, which reflect its content and concept.

PART I: Analysis of load and power losses in the engine and the network of Kolubara mining basin

- Power supply and consumption of electricity of MB Kolubara from 110/35 kV substation Vreoci;
- Analysis of electricity consumption, active and reactive load of 110/35 kV substation Vreoci;
- Analysis of the voltage and current harmonics and the danger of appearance of resonance in the 6 kV network of MB Kolubara;
- Calculations and analysis of load of engines connected to 0.4 kV and 0.6 kV network;
- Calculation and analysis of power losses and voltage drops in 6 kV, 20 kV and 35 kV network;

PART II: Preliminary Design of reactive power compensation in the network of MB Kolubara, fields "B", "D" and part of OPM Tamnava

- Analysis and determination of the required capacity for reactive power compensation in the secondary network of 110/35 kV substation Vreoci;
- Dimensioning of individual compensation in the Open-pit mine - field "B" and field "D" and parts of Tamnava - Option 1;
- Inrush currents of capacitors connected to 6 kV network and dimensioning inrush current reactors;
- Risk assessment of appearance of resonance in the 35 kV and 6 kV network with capacitors for reactive power compensation;
- Mixed compensation with fixed sections of the capacitor, which form (anti)resonance filters with transformer's reactance;
- Preliminary cost estimation for the mixed compensation;

The analysis in the project shows an overall reduction of costs from 975 149 euro per year, which should be achieved based on the effects of implementation of reactive power compensation which has been pointed out in this preliminary project. Although voltage harmonic distortion  $THD(U) = 2-3\%$  is moderate, there is always a risk of increased resonant harmonic currents of 11<sup>th</sup>, 13<sup>th</sup>, 17<sup>th</sup>, 19<sup>th</sup>, even 23<sup>rd</sup> and 25<sup>th</sup> order. The reason lies in the fact that, in the network with motors (only), amplification factor of resonant harmonics is  $F_{re} \geq 10$ , and the resonance currents of the harmonic can reach values that can jeopardize the capacitors. Calculations and analyzes suggested installation of a filter capacitor section. Since this is a relatively expensive solution, a variant based on our solutions - patent "A method for forming anti-resonant filters in medium voltage electrical networks" and our technical solution "Method for preventing occurrence of resonance in networks with capacitors on the secondary side of the transformer HV(MV1)/MV", is proposed.

Size of Project: 382 pages

Finished in: 2013.