1. "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
   Project Manager: Srđo Mrđa, MSc.
   Associates: Saša Minić, MSc.
   Danka Kecman, MSc.
   Tijana Janjić, MSc.
   Ivan Stanisavljević, MSc.

   This project is a part of "Study of long-term prospective Serbian transmission network development up to 2020(2025)" where alternatives for 110, 220 and 400 kV transmission network development in Belgrade and its neighborhood are presented. Beside transmission network in Belgrade, parts of a network in the area of Pančevo and Smederevo, which are connected to considered network, are analyzed and presented. Results of analyses are presented in 5 chapters: introduction, energy data, analyses of network functioning and economy, conclusions and graphical and table illustrations.

   Based on results of load forecasting, techno-economical analyses and comparison of possible development variants, the most prosperous solution of transmission network further development in the considered area for the period up to the year of 2025 has been suggested.

   Size of Project: 39 pages
   Finished in: 2006.

2. "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
   Project Manager: Saša Minić, MSc.
   Associates: Gordana Radović, MSc.
   Ivan Jovanović, MSc.
   Maja Turković, MSc.
   Srđo Mrđa, MSc.
   Branislav Ćupić, MSc.
   Tijana Janjić, MSc.
   Milan Ivanović, MSc.
   Miloš Stojković, MSc.
   Maja Marković, MSc.

   Analysis of network's present condition (phase 1 of the Project) and load forecast updating (phase 2 of the Project) have been accomplished based on data from the year of 1997. Long-term directions (year of 2020) of network development (phase 3 of the Project) have been formed and dilemmas, which should be clarified by detailed analysis of network development variants, have been clearly segregated. Variants of network development have been formed and analyzed, both without (phase 4 of the Project) and with (phase 5 of the Project) appliance of 20 kV voltage, and the most economical plan, which fulfills previously defined criteria, has been suggested. Network has been considered in respect of adjacent distributive areas (Raška, Paraćin, Vrnjačka Banja, Trstenik, Jagodina). Initial network size: ~880 MV/LV substations. Population: ~235000.

   Size of Project: 588 pages
   Finished in: 2006.

3. "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
   Project Manager: Saša Minić, MSc.
   Associates: Gordana Radović, MSc.
   Ana Šaranović, MSc.
   Danka Kecman, MSc.
   Branislav Ćupić, MSc.
   Nada Obradović, MSc.
   Tijana Janjić, MSc.
   Andreja Rašić, MSc.

   Analysis of network's present condition (phase 1 of the Project) and load forecast updating (phase 2 of the Project) have been accomplished based on data from the year of 2003. Long-term directions (year of 2020) of network development (phase 3 of the Project) have been formed and dilemmas, which should be clarified by detailed analysis of network development variants, have been clearly segregated. Variants of network development have been formed and analyzed, both without (phase 4 of the Project) and with (phase 5 of the Project) appliance of 20 kV voltage, and the most economical plan, which fulfills previously defined criteria, has been suggested. Network has been considered in respect of adjacent distributive areas (Kraljevo, Kragujevac, Topola, Lazarevac). Initial network size: ~1050 MV/LV substations. Population: ~186000.

   Size of Project: 520 pages
   Finished in: 2006.

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

   Ordered by: Serbian Ministry of Science and Environment Protection
   Project Manager: Miloje Kostić, PhD.
   Associates: Nada Obradović, MSc.
   Ivan Stanisavljević, MSc.
   Branka Milutinović, MSc., Public Utility Belgrade Waterworks
   Golub Babić, MSc., Public Utility Belgrade Waterworks
   Nevenka Nikolić, MSc., Public Utility Belgrade Waterworks

   Projects for power factor correction have been realized for five largest consumers (pump station) that belong to Public Utility Belgrade Waterworks. They, individually, consumed from 7000-35000 MWh/year active and 4000-14000 Mvarh/year reactive energy. All five consumers spent about 40000 Mvarh, in 2005. In scope of project following is done:

   1. It is established that the reactive load duration curves are similar to corresponding active load duration curves, as load duration curves are formed by loads originated from 2, 3, 4 or 5 induction motors that derive pump with (approximately) constant loads and operate with constant power factor.
   2. Selection of power factor correction methods was started with individual power factor correction (IC) of induction motors on voltage 6 kV or 10 kV consumed ≥95% electrical energy mentioned pump stations. This procedure provided that motor power factors $\cos\varphi \geq 0.95$.
   3. If the tariff system stimulates reaching $\cos\varphi = 1$, mentioned IC should be supplemented with additional section of constantly switched on capacitors in every pump stations - this is the 2nd phase of project realization. With this, complete hybrid power factor correction would be realized.

   For mentioned variants of power factor correction:

   1. Control on high harmonics of capacitors selection was performed. It was shown that there is no risk from the fifth and seventh harmonics resonances occurrences.
   2. The maximum RMS values of inrush current were calculated, and if the multiple of the inrush current $I_{inrush,\,i}/I_{Ci,n} \geq 100$, selection of corresponding inrush inductances was performed.

   Energy (money) savings through project realization are emphasized:

   - 21 986 705 kvarh/year, only by individual power factor correction (IC), and.
   - Additional 16 205 300 kvarh/year, by realization project's 2nd phase.

   Based on analyses about of total costs and total effects, it is concluded that:

   - Net return of investment (NROI) is 1.367 years (or 16.4 months), for total project, and

- For the 1st phase of project realization, Net return of investment (NROI) is only 0.895 years (or 10.8 months).

This is very profitable investment.

Size of Project: 71 pages
Finished in: 2006.

5. "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
Project Manager: Saša Minić, MSc.
Associates: Tijana Janjić, MSc.
Miloje Kostić, PhD.
Milan Ivanović, MSc.
Branislav Ćupić, MSc.
Maja Marković, MSc.
Dragan Popović, PhD.
Miloš Stojković, MSc.
Srđo Mrđa, MSc.
Nada Obradović, MSc.

Based on three relevant states (maximal, minimal and medium) of Serbian transmission network analysis of power flows and voltage conditions is performed. Reactive power flows and voltages are audited and critical network spots are emphasized. Effects of previous reactive power reduction as a consequence of low voltage reactive power compensation in the amount of 200 Mvar are analyzed and their high profitability is accented. Techno-economical analysis showed optimal group of 110/X kV substations for reactive power reduction by low voltage reactive power compensation in the amount of 170 Mvar. Special analysis if performed for medium voltage reactive power compensation in the amount of 30 Mvar. This analysis also included aspects of higher harmonics, and space in substation for compensation realization etc. Substations 35/X kV with high profitability rates of medium voltage reactive power compensation and amount of this compensation are represented.

Size of Project: 197 pages
Finished in: 2006.

6. "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
Project Manager: Dragan Popović, PhD.
Associates: Saša Minić, MSc.
Tijana Janjić, MSc.
Milan Ivanović, MSc.
Maja Marković, MSc.
Miloje Kostić, PhD.
Viktor Maksimović, MSc.
Dušan Arnautović, PhD.
Đorđe Stojić, PhD.
Slobodan Bogdanović, MSc.
Jasna Dragosavac, MSc.

Main purpose of this study was to propose solution for improvement of Serbian transmission network voltage/reactive power state in order to improve energy efficiency of transmission network. This task is realized through nine chapters, beside introduction. Global survey of reactive power consumption and actual and prospective possibilities of reactive power production is presented in Chapter 2. Detailed survey of reactive power consumption by nodes in Serbian transmission network and by specific time of the year is presented in Chapter 3. Based on available data, model sensitivity to modeled loads errors is inspected. Reactive power consumption and production balances by specific areas and by actual and prospective (2010. and 2020.) maximal and minimal network states are analyzed in Chapter 4. Detailed reactive power audit for 2006 and 2010 maximal and minimal network states is performed in Chapter 5. Isolated and interconnected network operations are considered. Based on these analyses and based on comparison of states before and after large compensation accomplished during 2005 (total amount 222 Mvar), analysis of Serbian

transmission network reactive loads reduction profitability is performed. Profitability, which is consequence of active losses reduction, is outstanding. Survey of reactive power compensation solutions, worldwide applications and possibilities of their applications in Serbia are presented in Chapter 6. Modern transmission network reactive power sources planning techniques are presented in Chapter 7. Conclusions are presented in Chapter 8, references in Chapter 9, and graphical illustrations in Chapter 10.

Size of Project: 159 pages
Finished in: 2006.

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

   Ordered by: Public Utility "Elektroprivreda Srbije", Belgrade
   Project Manager: Dragan Popović, PhD.
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   Saša Minić, MSc.
   Srđo Mrđa, MSc.
   Tijana Janjić, MSc.

   Detailed analyses of realized transmission network maximal states in 2005, and 2006, prospective maximal states in 2010, and 2015, minimal state in 2005 and prospective minimal states in 2010, and 2015 are performed. Possibilities of balance fulfillment in transmission network isolated (fictitious) operation are inspected. Actual and future interconnected operation of transmission network without significant problems related to reactive power flows is ratified.

   Contingency analyses, considering single and multiple outages, different scenarios of generators engagement analyses, and different total exchanges scenarios (5) analyses asserted that only motif for additional reactive power compensation are active and reactive power losses reduction and engaged generator reactive reserve increase.

   It is approved that it is possible to realize satisfactory voltage/reactive power conditions for prospective minimal states in 2010, and 2015.

   The best techno-economical solutions for installing new reactive power sources (location, capacity, number of compensators, connection voltage level, price) are obtained by applying developed optimization procedure and presented. Expected effects of reactive power sources installation are calculated and presented. Effects are in active and reactive power losses reduction, generators reactive power reserve increase and capacity of transmission network increase.

   The study consists of seven chapters, including introduction. Chapter 2 is methodological. Necessary and available energy data are considered in Chapter 3. Analyses of actual maximal and minimal transmission network states are presented in Chapter 4. Future network states in 2010 are analyzed in Chapter 5, and future states in 2015 are analyzed in Chapter 6. Conclusions are presented in Chapter 7.

   Relevant references are also presented in this study.

   Size of Project: 186 pages
   Finished in: 2006.

8. "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
   Project Manager: Saša Minić, MSc.

   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 is performed by detailed control of input data and applied methodology. It is ascertained that study conclusions are reached by inadequate techno-economical analyses and that they are wrong for the reasons presented in details in Revision.

   Size of Project: 4 pages
   Finished in: 2006.

9. "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
   Project Manager: Miloje Kostić, PhD.
   Associates: Ivan Stanisavljević, MSc.

   Thermal Power Plant "Nikola Tesla A" has six aggregates whose total power is 1652 MW.

   Its own consumption is about 8% of the plant's power (about 130 MW) as well as about 8% of total produced electrical energy. 6 kV asynchronous motors participate over 90% and 0.4 kV asynchronous

motors participate with about 5-6% in the thermal plant's own consumption. Within this study in the first phase the study "Energy analysis of own consumption and selection of proceedings for the rationalization" was made.

It contains 3 chapters:

1. Energy analysis of own consumption and loads, based on estimations and/or calculations of total losses in 6 kV and 0.4 kV asynchronous motors, and the structure of losses.
2. Selection of measures for the rationalization according to the analysis specified in previous thesis. For the rationalization of plant's own consumption (that is, of the electromotive drive), following measures have been chosen:
   - Identification of the optimal voltage values within U_n±5%, for the 6 kV network;
   - Selection of the consumers with economically justified reactive power compensation;
   - Application of asynchronous drives with the speed regulation for chosen drives and,
   - Individual energy rationalizations for 6 kV network, 6/0.4 kV transformers and motors.
3. The savings attained by rationalization of plant's own consumption have been estimated to 2400000 kWh per year and 30000000 kVarh per year.

The second phase included:

- Projects of concrete measures for reducing own electrical energy consumption;
- Realization of projected measures for reducing own electrical energy consumption;

Size of Project: 66 pages
Finished in: 2006.

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

Ordered by: Public Utility "Elektrodistribucija" Leskovac
Project Manager: Ana Šaranović, MSc.
Associates: Danka Kecman, MSc.
Miloš Stojković, MSc.
Branislav Ćupić, MSc.
Saša Minić, MSc.

The objective of this study is development of prospective 110 kV, 35 kV and 10 kV networks in the city of Leskovac for the period 2006 to 2025. The population of analyzed area is ~78000 (~28000 electrical energy consumers with 220000 MWh annual consumption and ~64 MW annual active power peak). The study includes analyses of energy consumption development for the period up to the year of 2005 as well as load and energy consumption forecast until the year of 2025. 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 those 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 2025 has been suggested. Initial network size: ~230 MV/LV substations.

Size of Project: 272 pages
Finished in: 2006.