

Summary of Existing Network Planning Criteria Used by the Black Sea Transmission System Operators (TSO's)

Based on the questionnaire that was given to eight Black Sea Region (BSR) Transmission System Operators (Armenia, Bulgaria, Georgia, Moldova, Romania, Russia, Turkey and Ukraine) about transmission network planning issues, it can be concluded that (Table-1):

- BSR TSO's are responsible for transmission network planning, and development plans have to be approved by national regulatory authorities, except Moldova and Russia.
- BSR TSO's are obliged by national laws to prepare transmission development plans, except Russia. The most often time horizons for planning are 1 year ahead and five years ahead (Short Term/Mid. Term).
- Transmission investments are mostly financed through transmission fees, loans, internal sources and private investors.
- Transmission Planning Criteria are published in national grid codes in most of the BSR TSO's, except Russia.
- The main technical criteria for transmission system development is the (n-1) security criteria, which is applied everywhere. It is mostly related to the loss of single line, transformer or generator, when following events are not permitted:
 - thermal overloadings of branches,
 - voltage declination below permitted range,
 - loss of stability,
 - loss of load,
 - interruption of power transits, and
 - disturbance spreading over power system;
- The (n-2) criteria is used in Bulgaria and Romania for grid connection of the nuclear power plant and in Turkey for grid connection of a generation equal to 1500 MW or more than that amount;
- Other technical criteria for transmission planning are not used, except in Armenia (where power and electricity balances, power flow), Georgia (realization of hydropower resources of high mountain areas and output of power energy from these regions), Russia (minimal reserve factors and no self-oscillations within the accepted operation regimes);
- BSR TSO's usually do not define different thermal ratings for winter and summer operational circumstances or for normal and emergency conditions. Different ratings are defined somewhere (Georgia, Romania, Russia and Turkey) for winter and summer operation with respect to the outside temperature;

- The most of the TSO's in the BSR have different ratings are defined somewhere for normal and emergency conditions with respect to the protection system settings, except Armenia, Georgia and Romania.
- There are no TSO's in the BSR which evaluates the probability of (n-1) events during transmission system planning except Armenia.
- BSR TSO's usually conduct load flow computations, security analysis, short circuit calculations and system stability analysis during planning process. Optimal power flows (Armenia, Bulgaria, Moldova, Turkey and Ukraine) and reliability analysis (Georgia and Romania) and static/dynamic analysis for post-emergency conditions only in Russia.
- Economic Criteria in transmission network planning are applied in most of the BSR TSO's, except Moldova and Turkey;
- Economic Criteria applied in Armenia (capital investment, IRR, NPV), in Bulgaria (no explanation), in Georgia (building costs and power losses), in Romania (net present value, benefit to cost ratio, internal rate of return, payback period), in Russia (lower cost option with equal technical efficiency) and in Ukraine (capital investments into construction of power transmission networks)
- BSR TSO's who apply for economical criteria usually estimate reduction of loss of load costs, reduction of the cost of losses and additionally to these alternatives benefit from telecommunication lines (Georgia), reduction of congestion costs and increase of transmission service revenue (Armenia and Romania), reduction of re-dispatching costs (Russia).
- Undelivered electricity costs across the BSR are changing between 1 to 10 Euro/kWh, in Ukraine less than 1 Euro/kWh, in Bulgaria more than 3 Euro/kWh and in Romania between 1-10 Euro/kWh. The other TSO's have not defined those costs.
- Generally, additional planning criteria are not applied for interconnection lines. Some countries apply different planning criteria based on the power transfer (Georgia), ITC and NTC maximization (Romania) and possibility of cross-border trade (Russia and Turkey).
- Uncertainties are mostly taken into account using multi-scenario analysis (Table-2). The most important uncertainties are:
 - new power plants size and location,
 - generators engagement,
 - load prediction,
 - country power balance,
- Risk assessments are not conducted by BSR TSO's, except Armenia.

The benchmarking tables about transmission planning issues among the BSR TSO's are presented as an attachment of this report.

Conclusions:

In evaluation of the questionnaires on this study we came to a conclusion that to give some view for possible needs and ways of harmonization of the used planning principles and criteria:

- Planning criteria used by the BSR TSO's are generally similar and mainly concentrated on (n-1) security criteria;
- Market oriented transmission investments and investments from regional perspective are not mentioned and it depends on the generally on the national grid codes;
- National transmission networks are mainly planned according to technical considerations and economic rationalization of new investments;
- Methods used by transmission planners are based on deterministic approach and probabilities of different events (network failures, generator dispatch, branches availability etc.) are not taken into consideration;
- In the BSR TSO's, transmission system planning process has to include different uncertainties in an open electricity market environment; the most important ones are generation investment plans with size and locations of new generators, generator bidding behavior in the future, hydrological conditions, branches and generators future availability, load growth and regional power balance. In the study, the most of the uncertainties are mostly taken into account using multi-scenario analysis.
- Transmission development in the BSR may be more effective if the following requests are to be fulfilled:
 - a) full independency of TSO's from production and supply companies;
 - b) acceleration of national authorization procedures for transmission facilities construction;
 - c) effective market design and stable regulatory framework;
 - d) take into consideration the market oriented signals for transmission investments;
 - e) direct communication to independent power producers instead of communication via regulatory body;
 - f) pro-active approach on security of supply by finding the answer on the question why parties are obtaining generation licenses, but are not build plants or postpone building plants;

- g) Contingency Analysis in system operation must be applied, it must be done also for planning of maintenance;
 - h) to deal with scheduling and balancing of wind generation
 - i) tendering for network losses
 - i) market balancing by taking into consideration the renewables (Bulgaria, Romania and Turkey);
 - j) coordination and full cooperation between the BSR TSO's in planning issues;
 - k) establishment of a stable financing mechanism that will support regionally important projects;
- BSEC is looking forward to develop a collaboration platform with EU in accordance with new development conditions of EU. And some of the member countries (Greece, Bulgaria and Romania) of BSEC are the members of the European Union and they are at the stage of complying their market rules with the EU market rules. On the other hand, some of the other BSEC countries are in the stage to enter to EU and they will pay the same efforts for harmonizing their rules with EU market rules. In this respect that their electricity systems will be in synchronous parallel operation with UCTE system .
 - So, the study results of the connection of Turkey to UCTE and UCTE-IPS studies are very important that after the connections has been completed the Turkey and IPS countries has to obey the UCTE rules while planning and operating their systems. So, if there is an official BSR transmission planning group which should be supported by EC then the common approaches will be available while planning data, establishment of planning scenarios, preparation of common network models for necessary analyses (load flow, dynamic, short-circuit, probabilistic models), performance of analyses, comparison of candidate projects. After the evaluation of these candidate projects according to the economic bases; the decisions must be given on the priority projects and the regional investments must be defined according to these results. Following to these results preparing reports concerning the BSR transmission system future bottlenecks, prediction of congestions from planning perspective and suggestions for further developments will be possible.

Table 1- Transmission System Planning Criteria among the Black Sea Region TSO's									
Transmission System Planning Criteria	Armenia	Bulgaria	Georgia	Moldovia	Romania	Russia	Turkey	Ukraine	
Responsibility for Transmission System Planning	TSO/ISO	TSO	TSO/Ministry	TSO	TSO	Others (Grid Comp. and System Operator are separated, there is no TSO.	TSO	TSO	
Work Investment Plan	LT	ST/MD/LT	ST/MT	ST/MT	MT/LT	NO	ST/MT	ST/MD/LT	
Approval from Regulatory Authority	YES	YES	YES	NO	YES	NO	YES	YES	
Financing of Transmission Investments	Trans.Fee/loans/ internal sources	Trans.Fee/ loans	loans / private	Trans.Fee/ loans/internal sources	Trans.Fee/ loans/ private	Trans.Fee/loans/ internal sources/ private	Trans.Fee/loans/ internal sources/ private	Trans.Fee/loans/ internal sources	
Documents related with the financing criteria	YES Other Documents	YES Grid Code/ Other Documents	YES Other Documents	YES/ Grid Code	YES/ Grid Code	NO	YES Grid Code/ Other Documents	YES Grid Code is under development/ Other Documents	
Age of (n-1) criteria	YES	YES	YES	YES	YES	YES	YES	YES	
Recent Thermal Ratings for Winter and Summer Regime	NO	NO	YES	NO	YES	YES	YES	NO	
Different Thermal Ratings for Normal and Emergency operation	NO	YES	NO	YES	NO	YES	YES	YES	
Location of the Probability of (n-1) events	YES	NO	NO	NO	NO	NO	NO	NO	
Technical Criteria	YES (power and electricity balances, power flow)	NO	YES (Realization of HP Resources of High Mountain Areas)	NO	NO	YES (minimal reserve factors and no self-oscillations within the accepted operation regimes)	NO	NO	
Studies during planning process **	LF-SA/OPF/ SC/ SS	LF-SA/OPF/SC/SS	LF-SA/ SC/ SS/ RA	LF-SA/OPF/SC/SS	LF-SA/ SC/ SS/ RA	LF-SA/ SC/ SS/ others (static and dynamic analysis for post-emergency conditions)	LF-SA/ OPF/ SC/ SS	LF-SA/OPF/SC/ SS	
Allocation of Economical Criteria	YES (Capital investment, IRR, NPV)	YES	YES (building costs and power losses)	NO	YES (net present value, benefit to cost ratio, internal rate of return, payback period)	YES (lower cost option with equal tech. efficiency)	NO	YES (capital investments into construction of power transmission networks)	
Use of undelivered energy (costs of load) per kWh	?	more than 3 euro/kWh	?	?	between 1 and 10 euro/kWh	?	?	less than 1 euro/kwh	
Additional Planning Criteria	NO	NO	YES/ Power Transfer	NO	YES/ ITC and NTC Maximization	YES/ possibility of cross-border trade	YES/ possibility of cross-border trade	NO	

ing into account constraints during planning cess	NO	YES	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
Analysis Techniques	YES	NO	NO	YES	NO	NO	YES	NO	NO	NO	YES	NO

short-term; MT: mid-term; LT: long-term
 2-SA: load flow and security analysis; OPF: optimum power flows; SC: short-circuit analysis; SS: stability simulations; RA: Reliability Analysis

Table-2 The most important uncertainties in Transmission System Planning among the Black Sea Region TSO's								
Uncertainties	Armenia	Bulgaria	Georgia	Moldovia	Romania	Russia	Turkey	Ukraine
New Power Plants Size & Location			✓	✓	✓	✓	✓	
Generators engagement			✓		✓	✓	✓	✓
Hydrological Conditions		✓				✓	✓	
Existing Power Plants Decommissioning					✓		✓	✓
Load Prediction		✓	✓	✓	✓	✓	✓	✓
Branches Availability			✓		✓		✓	
Regulatory and market issues							✓	
Market Transactions							✓	
Country Power Balance		✓		✓	✓		✓	✓

Conclusion: Most of the countries which take into account uncertainties during transmission network planning, use multi-scenario analyses approach for modeling