Concept for Development of Electricity Transmission Grids in Armenia

Energy is the most capital-consuming sector of economy and, besides, its operating conditions are subject to significant technical limitations (on quality, reliability, security, sustainability, etc.). Hence, ensuring development of the power transmission networks is connected with the necessity of attracting the substantial investments. At the same time, as mentioned in the materials of International Energy Agency, since the systems of power transmission and distribution are the natural monopolies, implementation of large 'strategic' investments in the power grids might create disadvantages for development of the other energy sectors (for instance, strategic investments might result in increasing the grid margins to the extent suppressing incentives for development of the new generation capacities).

Based on the analyses of current status of power supply system in Armenia, the main directions for development of transmission networks have been identified.

The current transmission system of Armenia is represented with the 220 kV grids of 1,323 km of total length and 14 substations, as well as inter-system 110 and 220 kV connections with all the neighbouring power systems.

In 2006, based on the order of Ministry of energy of RA, JSC Institute Energosetproekt developed the Scheme for Development of 220-110 kV Electricity Networks of Armenian Energy System. The work reviewed issues of ensuring power flows both for providing the reliable supplies for prospective consumption within RA and interconnections with the neighbouring systems.

The work also envisages construction of two new high-voltage 400 kV AC lines from Razdan TPS to Tbilisi GRES by 2010 and to Tavriz Sub-station (Iran) by 2013, as well as construction of one high-voltage 400 kV AC line from Armenian NPS to 400 kV transmission networks in Turkey by 2016. Giving preference to the above voltage standard is connected with implementation of strategies for integration of Armenia into regional electricity markets.

The studies have been conducted through modeling the full 220-110 kV schemes and with consideration of new 400 kV lines. The calculations were carried out in *Interactive Power Flow and Transient Stability Process* software, developed by one of the largest US power supplier - Bonneville Power Administration. The analyses of calculation results allowed drawing up the recommendations on necessity of consideration of input-output scheme for 400 kV line Iran-Armenia at Shinuair sub-station for providing allowable voltage levels in the system; installation of reactor with capacity up to 440 MVA for ensuring the voltage regimes and reactive capacity, as well as strengthening (increasing transmission capacity) of 110 kV Vinyl and Caoutchouc HV lines after 2015.

Currently, number of works for surveying transmission system regimes in Armenia in its parallel operation with energy systems of Black Sea Region countries and Iran are being carried out.

In particular, the Fichtner Company studied issues related to development of power transmission networks of Armenia and Georgia, in conditions of strengthened links with the neighbouring energy systems. As a basic option for Armenian energy system, construction of single 400 kV AC HV line from Razdan TPS (Armenia) to Ksani (Georgia) and construction of double 400 kV AC HV line from Razdan TPS (Armenia) to Agar (Iran). The calculations for forecasted scenarios of maximum and minimum loads in 2012 and 2015 have been carried out.

Calculations of the established operation regimes of the existing transmission system of Armenia were carried out by the *PSS/E* software package, which is developed by Siemens Power Transmission and Distribution INC and is used as unified basic calculation tool in UCTE countries.

Analyses of the calculation results for load flow in maximum and minimum load regimes indicate towards existence of rather high transmission capacity reserves in the elements of the transmission system. At none of the existing elements of power transmission lines the currents exceeding long-term allowable levels were observed; the transformer loads are within 60-70% values of the rated capacities; none of the nodes of the system demonstrate inadmissible (more then 5%) voltage deviations.

Check of energy system reliability on basis of (n-1) criteria carried out with *PSS/E* software package demonstrates that it is necessary to strengthen certain nodes of Armenian power system.

For instance, in order to eliminate overload on 220 kV Gardabani (Georgia)-Alaverdi (Armenia) line, it is recommended to install phase-shifting transformers 2X600 MVA at 400 kV sub-station in Ksani (Georgia).

The close to the critical loads in 220 kV grid can be expected on 220/110 kV transformers at Alaverdi, Shiuair and Ararat sub-stations, while check on basis of (n-1) criteria show that loads exceeding critical can be expected at 6 HV lines and 6 transformers.

In 110 kV grid close to critical loads can be expected on Caoutchouc, Vinyl and Nork HV lines, while, according to check on basis of (n-1) criteria, loads exceeding critical – on 4 HV lines. In case of cutout of 400 kV Razdan TPS (Armenia)-Ksani (Georgia) HV line, overload is probable on 220 kV Gardabani (Georgia)-Alaverdi (Armenia) and Alaverdi-Vandzor HV lines.

Analyses of dynamic and aggregate sustainability carried out by Fichtner Company indicate towards existence of the sufficient reserve for implementation of primary regulation. Though, there is essential need in modernization of regulating systems at the power stations.

Calculation of power balance in Armenian transmission systems has been carried out by *РАПЭ1* software package developed by JSC Scientific-Research Institute for Energy. The software uses АСКУТЭ data (in form of half-hour voltage and active and reactive capacities measurements during the calculation period – one month) as initial information on active parameters of the power network.

Analyses of the fault rate indicators for transmission system of Armenia indicate towards existence of the certain problems in emergency management systems. It is expected that significant improvement in this direction will be achieved following introduction of dispatch management system – *SCADA*. Besides the mentioned, the *SCADA* will increase capabilities of TSO I the field of implementation of economic dispatch systems. In any case, final decisions on the composition of switching equipment and emergency management systems shall be made in the context of integration of Armenian energy systems into regional energy markets.

Conclusions

1. In order to ensure integration of Armenian energy systems into regional energy markets, it is necessary to develop 400 kV voltage class and construct new interconnections with power systems of Georgia, Iran and, consequently, Turkey.
2. Establishment of interconnections by 400 kV lines will result in necessity of strengthening separate nodes of 110-220 kV transmission and distribution grids in Armenia.
3. Introduction of SCADA system will ensure observance of technological limitations and increase of manageability of Armenian power system, as well as more effective application of economic dispatch principles.
4. Composition of emergency management means in transmission grid shall be revised along with integration of Armenia to the regional energy markets.