POWER GRID INTERCONNECTION IN NORTHEAST ASIA: VIEW FROM EAST RUSSIA

Sergei Podkovalnikov
Energy Systems Institute, Russian Academy of Sciences, Siberian Branch

Current state and perspectives of East Russian electric power industry. Electricity consumption of East Russia is distributed very unevenly over territory. Major share of the consumption concentrated in the South part of the region. This share is met by Interconnected electric power systems (IEPSs) of Siberia and Russian Far East (RFE). Electricity needs of North and Northeast territories are met by local electricity sources. East Siberian and Russian Far East power interconnections (ESPI and RFEPI accordingly) will be considered in the presentation. Their total current generating capacity is nearly 42 GW. Nearly 85 % of this capacity is located in ESPI. About two thirds of East Siberian power interconnection capacities are installed on hydro power plants (HPPs). There are four very large HPPs there including Sayano-Shushensk (6.4 GW), Krasnoyarsk (6 GW), Bratsk (4.5 GW) and Ust-Ilimsk (3.8 GW). Unlike East Siberia, Russian Far East IEPS is mostly based on thermal generating capacities. More than 80 % of capacities are installed on thermal power pants of RFEPI. Back-bone power grid of ESPI and RFEPI is made up by 220 and 500 kV transmission lines.
According to plans of national economic development, the highest electricity consumption for ESPI and RFEPI, having taken place in 1990, is to be restored by about 2010. By the year 2025 electricity demand for the region will increase by nearly 60 % more. To meet this demand capacities of ESPI and RFEPI power plants are to grow to about 64 GW.

Potential effects of electric power systems (EPSs) interconnection in Northeast Asia (NEA). The major effects are as follows:

- Decrease of required installed capacity of power plants as a result of the fact that combined annual load maximum of consumers in interconnected power system is less than the sum of EPS annual maxima at their separate operation. This difference is especially large when annual load maxima in interconnected power systems take place in different seasons of the year. This is the case for NEA region;
- Decrease of fuel cost due to possibility of joint optimization of operating conditions in interconnected power systems;
- Improvement of interconnected power systems reliability or decrease in required capacity reserves with the same reliability (emergencies of interstate electric ties – ISETs – are also taken into consideration);
- Environmental effect can be gained when ISET makes possible involving into power balances of Northeast Asian countries large environmentally cleaner power plants (hydro, nuclear or tidal), which otherwise will not be constructed (or will be constructed in the very remote future).

In Russia, North provinces of China, Korea People Democratic Republic (KPDR) and Mongolia the annual load maximum is in winter in the evening hours and in Japan,

Republic of Korea (ROK) and South provinces of China it is in summer in daytime. Interconnecting EPSs of these countries will bring about sufficient effect of power plants capacity saving. The effect is realized in the following way.

In EPS with the winter maximum electric load during summer period of electricity consumption decrease, temporarily unused capacities of thermal power plants (TPPs) can be additionally loaded. The additional power generation can be transmitted to EPS with the summer load maximum, meeting peak load and replacing TPPs in energy and power balances there. In winter period, to the contrary, TPPs of power system with the summer load maximum can be additionally loaded and their generation will be transmitted to EPS with the winter load maximum. Thus, installed capacity of power plants in power systems with different seasons of load maxima can be decreased by only commissioning intersystem/interstate electric ties connecting them. This decrease in each EPS will be approximately equal to an ISET transfer capability. The total value of potential effect of capacity saving due to interconnection of EPSs with different seasons of load maxima can reach 30-40% of the capacity of a smaller EPS (it is equal to seasonal fall in power demand). This effect makes ISET much more feasible than in the case of the one-season load maxima.

Perspective electric ties of East Russia with Northeast Asian countries. Russian research and design organizations have studied the perspectives for developing electric ties between EPSs of East Russia and NEA countries. These ISETs can serve both for electricity export and realization of power interconnection effects. The first priority projects are considered to be ISETs with North provinces of China and North and South Korea.

Newly studied is ISET “Russian Far East – KPDR – ROK”. Special mathematical models worked out at Energy Systems Institute for optimization of generation capacity mix and transfer capability of interstate electric ties and evaluating reliability of EPSs were implemented. The results obtained showed the following.

Total commissioning of generating capacities decreases by nearly 8 GW when interconnecting the considered EPSs in comparison with their separate operation. This makes up about 25% of new capacities to be commissioned at separate operation of EPSs. The obtained magnitude of saving the capacities owing to ISET is comparable with current capacity of the whole interconnected EPS of Russian Far East. When interconnecting capacities of power plants reduce in EPSs of KPDR and Republic of Korea. Installed capacities of RFE IEPS increase somewhat compared to the separate operation. Such redistribution is due to lower costs of electric power production by Russian Far East power plants.

The total decrease in capital investments for power plants in the case of EPSs interconnection makes up $ 14.3 Bln. ISET cost was estimated at about $ 2 Bln. Thus, resulting decrease in demand for capital investments is $ 12.3 Bln. Comparison of annualized costs for the cases of separate and interconnected operation of EPSs showed

that the latter case has the lower cost ($ 14.3 Bln./year against $ 16.2 Bln./year). This means that ISET is economically efficient.
Substantial positive annual economic effect due to construction of ISET “RFE – KPDR – ROK” will take place for each country-participant. It makes sound economic grounds for interconnecting power systems of NEA countries.

Methodology for study of interstate electric ties in NEA region. Study of ISETs effectiveness has special features and meets certain difficulties. A number of tasks take place at ISETs effectiveness assessment. These tasks are: a) optimization of capacity mix of interconnected EPSs; b) determination of EPSs reliability indices; c) optimization of operating conditions of interconnected EPSs and ISETs; d) determination of export-import tariffs; e) assessment of energy, economic, financial and environmental effects of ISETs in total and for each country-participant; f) splitting up costs of ISETs among countries-participants; g) ensuring energy security for countries-participants.
Working out appropriate methodology, including methods and mathematical models, to solve the above tasks is required. Such a methodology is being devised by Energy Systems Institute.

Formation of power grid interconnection in Northeast Asia. Construction of ISETs in Northeast Asia though resulting in great effects will meet the following barriers: a) dependence of countries-participants on external electricity supply; b) different technical standards in power industry in various countries of the region; c) different energy legislation in countries of the region; d) long distances, difficult routes and high cost for ISETs; e) financing and others. However these barriers can be overcome by cooperative efforts of concerned countries.

Formation of ISETs and power grid will require various activities. These are concluding agreements among interconnecting countries, joint working out legal, prescriptive and methodological basis for constructing ISETs, formation special bodies for maintaining and developing interstate power grid in the region, etc.

Nowadays there are just a few weak transmission lines between NEA countries. Thus, formation of power grid interconnection in Northeast Asia will start from the scratch. That is why, it will proceed by stages, which can be set up presumably only.

At the first stage, as can be supposed, the domestic transmission lines within China and East Russia will be reinforced and some primary ISETs will be constructed. These are supposed to be electric ties between Russia and China, Russia and KPDR and ROK. Electric ties between Mongolia and Russia will be reinforced. The length of the first stage can be tentatively assumed up to the years 2020 – 2025. On the whole, the first stage of power grid formation will be characterized by the isolated or bilateral solving the problems of construction and control of power flows for each ISET.

The second stage of power grid formation will start after the constructed ISETs begin to affect noticeably the energy and power balances and operating conditions of the interconnected EPSs. Here, the power flows on individual ISETs can affect operating

conditions of several EPSs. There can be transit flows across some countries (for instance across KPDR from East Russia or China to Republic of Korea), etc. This will require coordination of ISETs construction and regimes of power flows among several countries and later, probably, within the whole NEA power grid.

Conclusion. The following inferences can be drawn from the above said:

- Power integration of the Northeast Asian countries with formation of interstate electric ties and power grid interconnection will bring about substantial effects to the countries-participants.
- There are barriers to power systems interconnection in NEA region but they can be overcome by cooperative efforts of countries-participants.
- Development of methodology, mathematical models and collecting information on power industries of Northeast Asia Countries for studies of power grid interconnection project are required.
- Cooperation of all concerned organizations of various countries is needed to develop Northeast Asia power grid interconnection project.