Electricity Cooperation Between Russia and Mongolia: From Bilateral Collaboration to Participation in the Northeast Asia Power System Interconnection

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***Abstract* — The paper discusses the development of electricity cooperation between Russia and Mongolia. Historically, bilateral Russian-Mongolian electricity cooperation has developed along two lines. As part of the first direction, Russia designed and supplied equipment, built, and provided loans for the construction and reconstruction of electric power facilities in Mongolia. The second direction involved cross-border trade in electricity and power. To arrange bilateral electricity cooperation, the necessary regulatory framework was established in the form of cooperation agreements between government agencies and energy companies of Russia and Mongolia. The Russian-Mongolian Intergovernmental Commission acts as a kind of catalyst for the signing of these agreements and ensures contacts between the interacting parties. In the future, with the establishment of the cross-border power system interconnection in Northeast Asia and the creation of new cross-border power grid infrastructure, bilateral Russian-Mongolian contacts will be taken to the next level and grow into multilateral regional electricity cooperation within the framework of the said power interconnection. According to the optimization calculations performed in this research, the role of Mongolia as a supplier of renewable energy to the regional cross-border electricity market will increase, and electricity trading between Mongolia and Russia, Mongolia and China, and Russia and China (through Mongolia) will be dramatically strengthened for the mutual benefit of all countries within the cross-border power system interconnection.**

***Index Terms*: Electricity cooperation, cross-border interconnectors and power system interconnections, electric power, capacity, agreements, expansion prospects.**

I. Introduction

Bilateral electricity cooperation between Russia and Mongolia has a long history. During the Soviet period, the USSR actively participated in the creation of Mongolia's electric power industry at the stages of designing, supplying equipment, and constructing power generation and grid facilities. The central power system (CPS) of Mongolia has been connected for parallel operation to the Interconnected Power System (IPS) of Siberia and, through it, to the Unified Energy System (UES) of the USSR since as early as the 1970s. Cross-border Soviet-Mongolian interconnectors ensured the trade in electric power and energy, improvement in the operation of power equipment, an enhancement in the efficiency of the power systems, and the power supply reliability. In the post-Soviet period, Russian-Mongolian electricity cooperation continued along the above lines.

In the future, a cross-border power system interconnection (CBPSI) is expected to be established in Northeast Asia (NEA), with Russia and Mongolia as its participants. In this regard, bilateral electricity cooperation between these countries will be transformed into multilateral one within the framework of this CBPSI. At the same time, bilateral cooperation is taken to the next level with the intensification of trade in power and electricity, using the new cross-border power grid infrastructure to be created within the framework of the Northeast Asia Power System Interconnection (NAPSI). In what follows, the issues of cross-border Russian-Mongolian electricity cooperation will be discussed in more detail.

II. Bilateral electricity cooperation

Mongolia's electric power industry was created with the active support on the part of the USSR. As a case in point,

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Table 1. Electricity trading between Russia and Mongolia, GWh.

	2010	2015	2019	2020	2021
Russia–Mongolia	214	263	372	312	487
Mongolia–Russia	21	21	27	4	23

in the 1950s and 1980s, seven coal-fired thermal power plants were built there with the predominant participation of Soviet experts: four plants in Ulaanbaatar and one plant in each of the following settlements: Darkhan, Erdenet, and Choibalsan. Today, these plants, the so-called combined heat and power (CHP) plants, which generate electricity and heat, are the basis of Mongolia's centralized energy supply. They produce up to 4/5 of the country's electricity [1].

At present, as part of bilateral cooperation, Russia continues to deliver power equipment, participate in the modernization of power plants in Mongolia, and provides funding for them. For example, the modernization of Ulaanbaatar CHPP-4 was completed in 2021 [2]. The cost of the project exceeded $160 million, with funding provided in part by VEB RF [3]. The Ural Turbine Works designed and manufactured the turbines. ELSIB Research and Production Association supplied three new generators with increased capacity. The new plant units have a lifespan of at least 40 years, during which time each of the turbines will save up to $19.5 million in fuel costs annually, producing 10% fewer air emissions than the old equipment. The efficiency of the new machines increased by 9%, and their maneuverability increased by 40% [4]. As a result of the modernization, the installed capacity of CHPP-4 increased from 540 MW to 752 MW [3].

At present, the Russian energy company InterRAO-Export is developing a feasibility study for the modernization of CHPP-3 in Ulan Bator [5]. The modernization project will be financed through the Russian export credit. The modernization of CHPP-3 will improve the reliability of heat and electricity supply to the capital of Mongolia.

Electricity trading between Mongolia and Russia is an important strand of electricity cooperation between these countries. Table 1 shows the volume of electricity trading since 2010.

As seen in the Table, electricity exports from Russia exceed the transmission of electricity from Mongolia to Russia. This is due to the fact that the transmission from Mongolia is of a flow-based nature when the Mongolian base-load and low-maneuverable thermal power plants are not unloaded during the dips in daily load profiles but deliver electricity to Russia (IPS Siberia). IPS Siberia, with its considerable flexibility due to the large maneuverable hydropower capacities has the ability to reduce and redistribute the load at its power plants by receiving the flow from Mongolia. The presented scheme of interaction between the Mongolian power system and IPS Siberia is actually a description of the manifestation of the system-wide power flow effect that occurs when power systems are integrated.

Figure 1 shows the 110 kV and 220 kV tie lines between Russia and Mongolia. Work is constantly underway to modernize these interconnectors. For example, in 2015, the Russian party replaced current transformers at the 220 kV Selenduma substation of IDGC (Interregional Distribution Grid Company) of Siberia, a subsidiary of PJSC Rosseti, which made it possible to increase the maximum allowable power flow in the controlled section «Selenduma–Darkhan» from 175 MW to 245 MW. This substation is part of the 220 kV transit system that provides parallel operation of the Mongolian energy system with the UES of Russia.

In 2022, emergency control systems were put into operation at the Selenduma 220 kV substation. At the same time, the transfer capability of the grid transit line, which is used for exporting power to the Mongolian power system, increased by 100 MW to 345 MW.

Bilateral Russian-Mongolian cooperation is backed by a solid organizational and regulatory basis. There is a Russian-Mongolian intergovernmental commission on trade and economic, as well as scientific and technological cooperation, which ensures close contacts between Russian and Mongolian government agencies and power companies. These contacts are backed by various kinds of agreements. Figure 2 shows the Russian-Mongolian agreements over the past decade and beyond that have shaped the legal framework for electricity cooperation. As can be seen, these agreements are made both between government agencies and between energy companies.

The above agreements focus on the issues of power grid construction, implementation of joint projects for reconstruction and modernization of electric power facilities, construction of electric power generation facilities, including highly maneuverable regulating capacities and renewable energy sources in the Russian Federation and Mongolia. Within the framework of these agreements, the parties shall assist the economic entities of the party countries in amending or prolonging the documents, which, in particular, concerns the agreement on technical support for parallel operation, the organization of information exchange, and on the organization of metering of power flows through cross-border power lines.

It is important to note that the bilateral Russian-Mongolian electricity cooperation discussed above actually lays the foundation for multilateral cooperation in Northeast Asia. In particular, the 2019 Agreement between the Government of the Russian Federation and

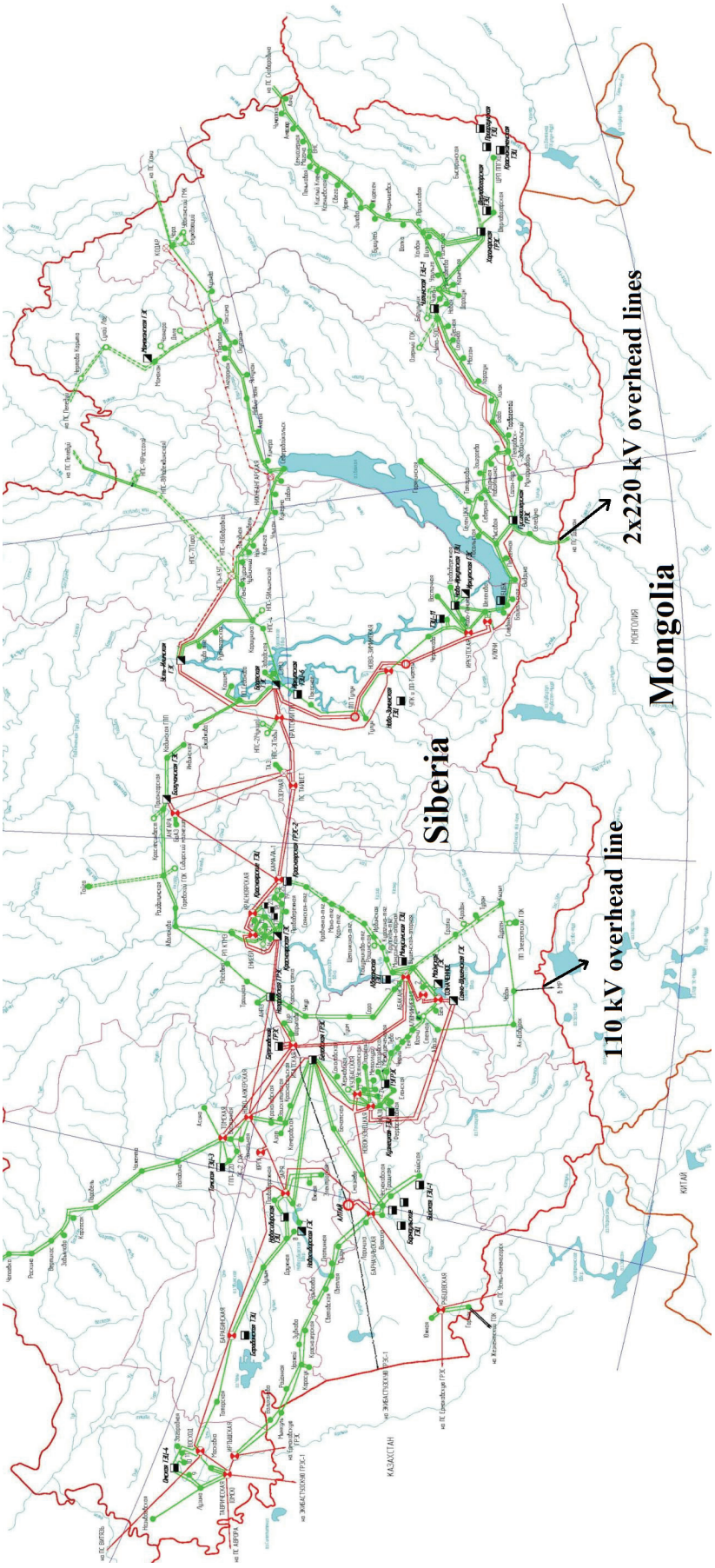

Fig. 1. Russia-Mongolia interconnectors.

Fig. 2. Organizational and regulatory system of bilateral Russian-Mongolian electricity cooperation.

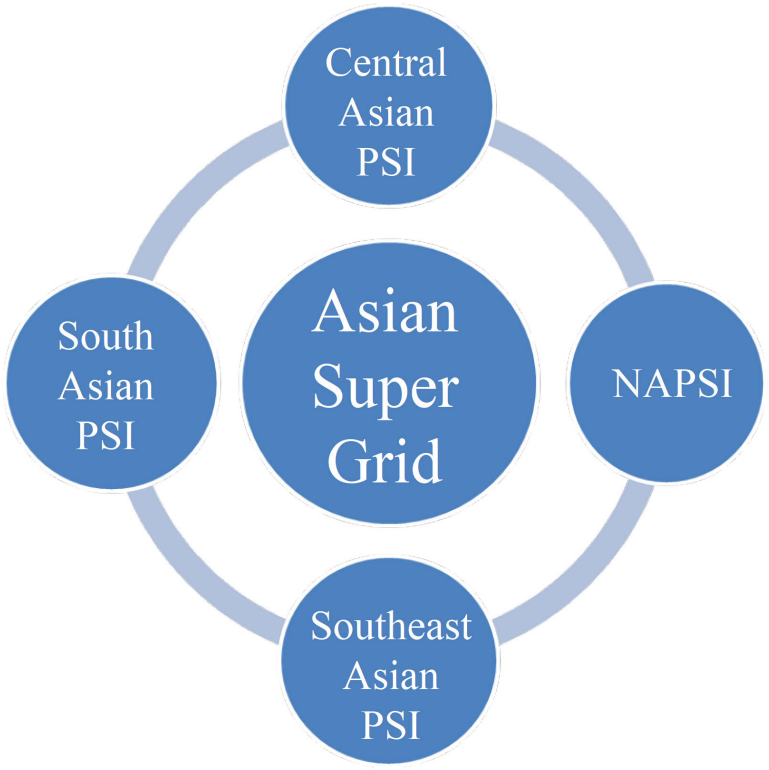

Fig. 3. Establishment of the Asian Super Grid.

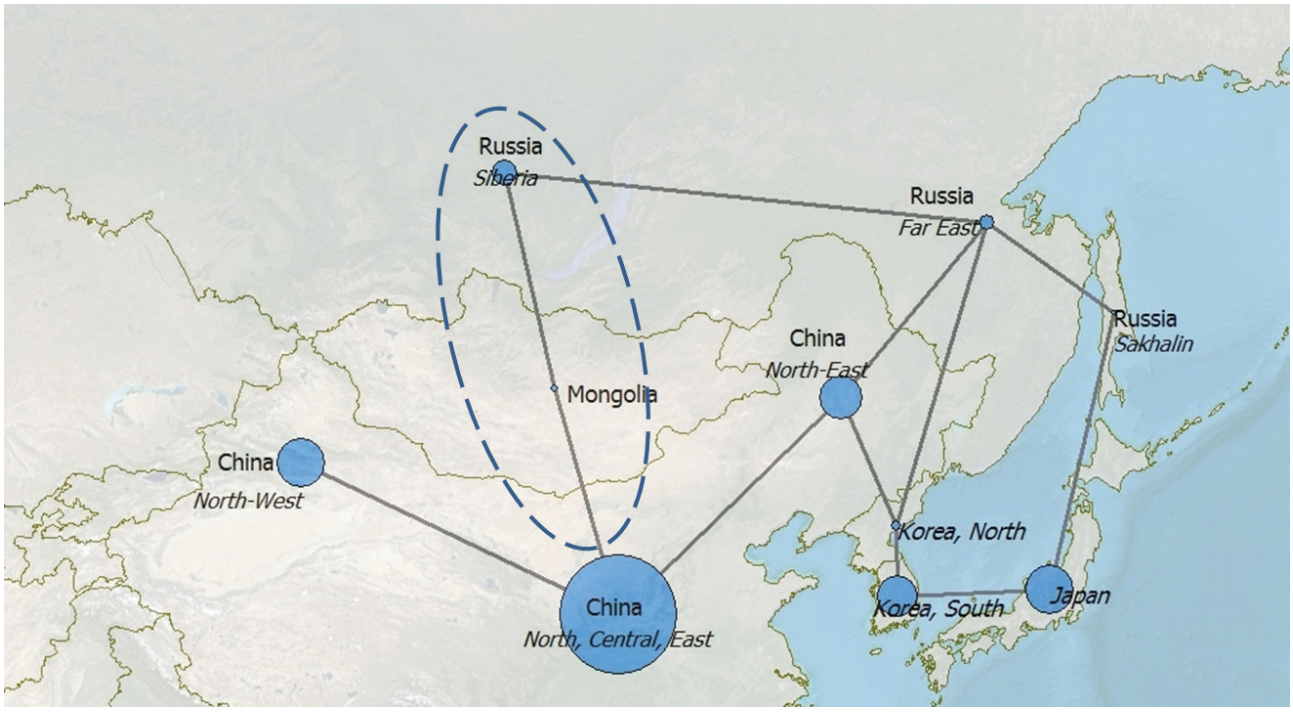

Fig. 4. Diagram of PSI in NEA.

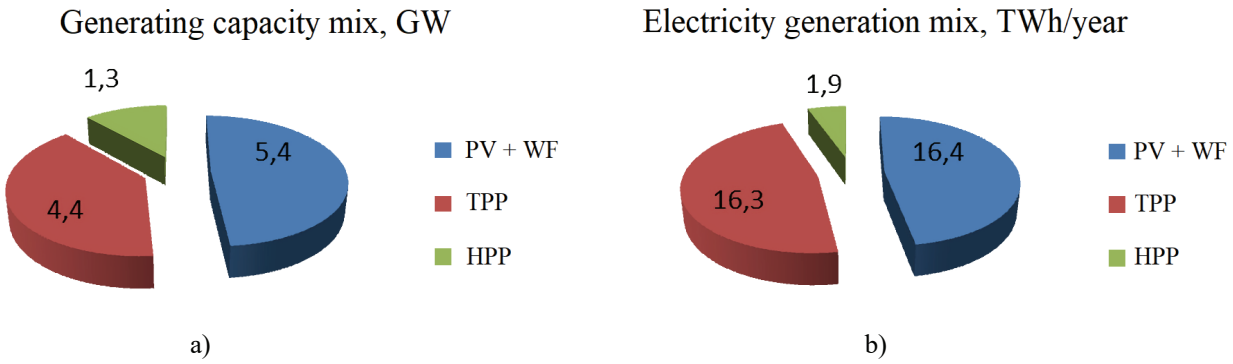

Fig. 5. Installed capacity (a), electric energy generation (b) by Mongolia, 2040, CO_2 tax = $90/t.

the Government of Mongolia on electricity cooperation notes the implementation of joint projects in electric power generation, electricity export/import to/from Mongolia, expansion planning for power grid facilities of Mongolia, including those used for the electricity transit to other countries. The document also suggests assessing the feasibility of a unified market of electric energy and power within the Russian Federation and Mongolia, and specifically as part of the integration of energy markets in Northeast Asia, etc. The 2019 Memorandum of Understanding between PJSC Rosseti and Erdenes Mongol LLC was signed for the purpose of long-term mutually beneficial cooperation in the research and development of integration links of power systems in Northeast Asia, including necessary priority measures to strengthen and improve the reliability of the power system and develop the electric power infrastructure of Mongolia. The memorandum noted that the parties agreed to form a joint working group to develop a common roadmap for the regional integration of NEA electricity markets, taking into account the modernized power system of Mongolia, conduct joint research, and conduct a feasibility study for the construction of new cross-border power lines.

III. Multilateral electricity cooperation

The conditions for multilateral electricity cooperation in Northeast Asia are currently being created. This is primarily due to the fact that the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) decided to support and promote the megaproject of an Asia Super Grid, including the CBPSI in NEA (Fig. 3).

The establishment of such a power system interconnection in the Asian region would contribute to the achievement of sustainable development goals, including carbon neutrality. In 2017, the UNESCAP established a working group on energy connectivity. This group participated in the development of a Regional Electricity Connectivity Roadmap, with strategies designed to promote cross-border interconnectors for sustainable development [6], and is currently involved in preparing a Regional Trends Report.

Studies on the NAPSI, carried out at the Melentiev ESI SB RAS [7, 8], show the technological and economic feasibility of this cross-border power system interconnection made up of six countries of the region, including Russia and Mongolia. With this interconnection, tie lines between the latter get substantially strengthened, and trading of electricity and power increases dramatically compared to the current bilateral Russian-Mongolian electricity cooperation.

Figure 4 shows a diagram of the prospective multilateral CBPSI.

It is assumed that with a multilateral CBPSI established in NEA, Mongolia will actively develop the Gobitek project based on renewable energy sources [9], which is of international importance. Its output will be transmitted to power grids in neighboring countries and will also be partially used locally to supply power to Mongolian consumers.

Below are some results of research on Russian-Mongolian electricity cooperation within the framework of the NAPSI, based on research presented in [8]. The input data and assumptions adopted were described in [8] and therefore are not given here. It is worth noting that a tax on CO_2 emissions was used to incentivize the introduction of renewable energy sources (RES) [10, 11]. The tax was assumed to be $90/ton of CO_2 emissions in order to assess the potential for the introduction of renewable energy sources in the power systems of the countries under consideration. The year 2040 was taken as the baseline year of the calculations.

Figure 5 shows the mix of installed capacity and electric energy generation in Mongolia provided this tax is introduced for the considered time frame. As can be seen, the share of RES, including only wind farms (WF) and solar photovoltaic power plants (PV), in the mix of generating capacity is about 49%, and its share in electricity generation slightly decreases, and amounts to about 47%. If conventional hydro power plants are added to wind farms and photovoltaic power plants, the share of all renewable energy sources in Mongolia will be 60% in terms of installed capacity and about 53% in terms of electricity generation.

The amounts of power, including those generated from

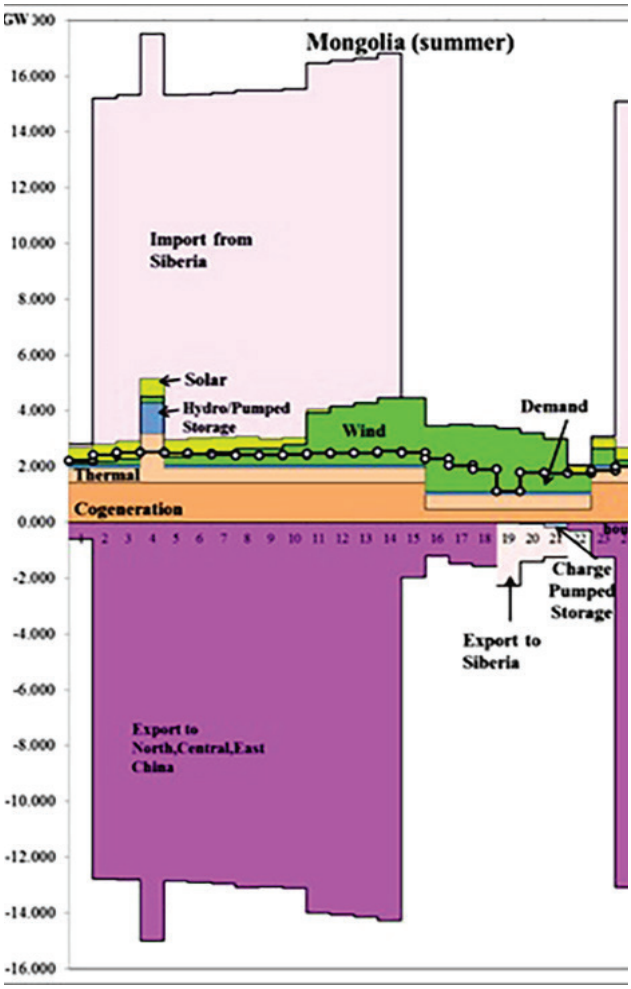

Fig. 6. Daily summer operating mode of Mongolia's power system, 2040, CO_2 tax = $90/t.

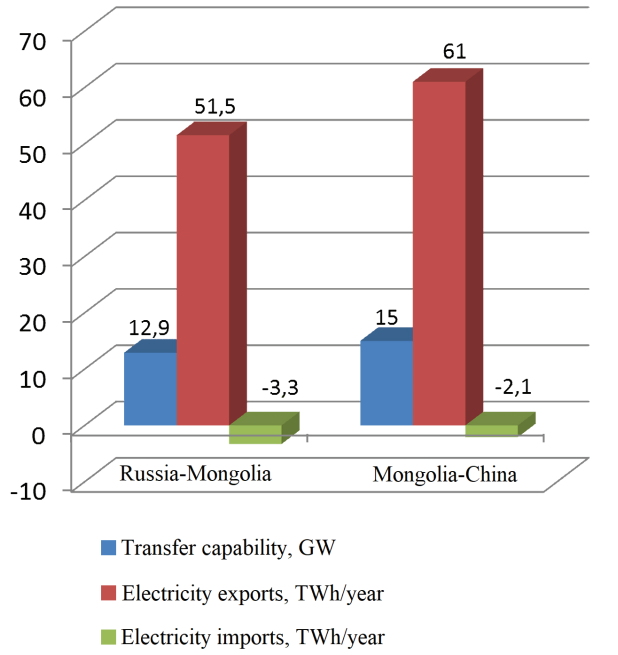

Fig. 7. Development of Russia-Mongolia interconnectors when forming a CBPSI in NEA, 2040, CO_2 tax = $90/ton.

wind and solar installations (Fig. 5) added as part of the Gobitek project, exceed the needs of Mongolia and are exported to electricity markets of neighboring countries, including Russia. These amounts were obtained by optimization calculations for the entire NAPSI for the time frame in question, and, accordingly, are optimal from the perspective of the entire power system interconnection.

Figure 6 shows the daily summer operating mode of Mongolia's power system. It also indicates electricity trading with neighboring power systems, including Russia (Siberia). As already noted, significant amounts of electricity are transmitted outside Mongolia, in particular, to Russia. A significant amount of Mongolia's energy imports come from Russia, and then this energy transits through Mongolia to China. The transfer capability of the Siberia-Mongolia interconnector in this case is about 13 GW, and that of the Mongolia-China section reaches 15 GW (see Fig. 7).

Apart from the transfer capabilities of cross-border interconnectors, Figure 7 shows the annual electricity trading between Russia and Mongolia and between Mongolia and China. Just as in the daily profile (see Fig. 6), on an annual basis (see Fig. 7), Mongolia, transmitting electricity abroad, is mainly a transit country through which energy is transmitted from Russia to China. It should be noted that the indicated diagram of flows was obtained by the optimization model considering the $90/ton tax on CO_2 emissions.

IV. Conclusion

Currently, there is active bilateral electricity cooperation between Russia and Mongolia, which is not limited to electricity trade, but also includes the participation of Russia in the design, construction, supply of power generating and electrical machinery, and financing of projects for expansion of electric power facilities in Mongolia. An appropriate regulatory and organizational infrastructure is in place to ensure such cooperation.

In the future, if the CBPSI is established in NEA, and Russia and Mongolia join it, electricity cooperation between these countries will be taken to the next (higher) level. The creation of a powerful grid infrastructure within the NAPSI will significantly strengthen interconnectors between Russia and Mongolia and increase electric energy and power trading, in particular for the more comprehensive use of highly variable and poorly predictable renewable energy sources, specifically those planned to be commissioned as part of the Gobitek project. Interconnectors with other countries will also be strengthened. Accordingly, the integration effects of the joint operation of the power systems of these countries, both bilaterally and multilaterally, will increase. All this will make a significant contribution to sustainable development and the achievement of carbon neutrality by Russia and Mongolia in the long term.

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