Asia International Grid Connection Study Group
Interim Report Summary

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Basic concept and roles of international grid connections

Transmission lines crossing international borders have been in use in Europe and North America for a long time. In recent years, the roles and value of grids have been increasing due to factors such as expansion in markets for electricity, use of power systems across wider areas, and, during recent times in particular, large-scale integration of variable renewable energy sources into the power systems. Another major background factor is technological developments that enabled to realize low-cost installation of high-voltage DC transmission lines even across asynchronous areas and over long distances under the sea. Electricity trade takes place across borders not only in Europe and North America but also in Asia, Africa, and Central and South America.

Interconnections provide the following benefits. First, it leads to improvements in economic efficiency through competition with more players. The greater the difference in electricity prices, the greater the benefit, a larger price-equalization effects. Competitive power producers can expand into overseas markets. Since electricity prices are subject to fine variations according to time of day and other conditions aside from average prices, there are no unilateral price differences on the part of power producers with high electricity prices. Second, inter-regional or international transmission operation contributes to a stable supply of electricity. A larger network makes it easier to balance supply and demand by integrating large numbers of power plants and consumers. While simple expansion in network size alone also has its drawbacks, such as the fact that a partial power failure will affect the entire network, today it is possible to achieve close coordination among multiple power transmission system operators (TSOs), due to recent progresses in information and communication technologies. Third, power grid operation promises flexibility, enabling large-scale integration of variable renewables such as solar and wind power. This both helps to combat climate change and contributes to increasing energy self-sufficiency. Also, having an interconnection available as one of a wide range of options contributes to security through diversification of risks. In addition, international economic transactions lead to relations of reciprocity. In Europe, interconnections have been in place since prior to World War II, in which nations within the region fought each other, and since the war political support for market integration has helped to maintain peace. The international transmission network is one symbol of such integration.

Increases in interconnections in Europe in recent years

Today in Europe, policy objectives at a pan-European level, such as market integration and integration of renewables, are having a major impact on the growth of interconnections, and grid operation methods and forms of investment have been changing too. While previously electricity transactions were conducted through interconnection based on mutual agreements among operators, during the 2000s the system shifted to one of explicit auctions, and furthermore in recent years they have been shifting toward transactions conducted through the market in the form of implicit auctions, so that today interconnection is in use through combination of both explicit auctions and implicit auctions. Revenues that can be secured through operation of an international power grid include (i) revenues from transmission rights based on explicit auctions and contracts among enterprises, (ii) revenues from congestion charges from differences in day-ahead market prices between two connected areas, and (iii) revenues from transmission fees, which are regulated rates. Particularly high levels of revenues from transmission fees and congestion charges can be expected between countries with high differences in electricity prices, and this accelerates incentives for

investment in interconnection businesses. In addition, ENTSO-e, in which all transmission companies in the Europe zone take part, plays important roles in both coordination and maximizing the efficiency of benefits in planning construction of transmission lines.

Benefits and characters of interconnections vary by country. One example is gains from differences in prices. Another is mutual use of supply thanks to high degrees of mutual complementarity arising from differences in power supply structures among countries. A third example is that of benefits arising from differences in daily demand and supply patterns and time zones. A fourth is accelerated use of interconnection as a means of securing flexibility, since the share of variable renewable energy sources is increasing. Specific examples from individual countries have their own distinguishing features. These include 1) Britain's plans for construction of numerous interconnections in response to high electricity prices, 2) Ireland's use of interconnections as one means of putting its wind power generating capacity to effective use, 3) the Netherlands' serving as a hub for European electricity transactions using its interconnections with multiple neighboring states, and 4) France's large-scale nuclear power generation.

The feasibility of an international power grid in Northeast Asia

A look at the feasibility of an international power grid in Northeast Asia, e.g. Japan, China, South Korea, Mongolia, and Russia, shows that in terms of geographical distance it is only 43 km from Cape Soya in Hokkaido to Sakhalin Island in Russia and no more than 200 km from the city of Fukuoka to Busan, South Korea—vs. a distance of 580 km covered by Europe's NorNed cable—so that physically speaking it would be worthwhile to consider interconnection. The greatest distinguishing feature of northeast Asia is the fact that multiple large-scale demand zones, centers of economic activity, adjoin each other—the four countries of Japan, China, South Korea, and Mongolia together constitute a vast market accounting for 76% of Asia's power generation and 77% of its power consumption. Electricity system-wise, each of these countries permits private-sector participation in their markets, including foreign investments, in its power-generating sector. In each of these countries other than Japan, unbundling is introduced, with the grid operated by a state-run transmission company (Japan is in the process of a legal unbundling planned for completion by 2020). While no international market for transactions in wholesale electricity yet exists, Japan, South Korea, and Russia each have their own wholesale electricity trading markets. There are high likelihoods that the state-owned transmission companies in China and Mongolia, Inter RAO in Russia, which is the electricity trading company and an effective state-run monopoly, and the state-run Korea Electric Power Corporation in South Korea could play leading roles in electricity trading, and not only is it easy for them to make arrangements with government administrators but these transmitting companies also are demonstrating proactive approaches to interconnection.

With regard to the benefits of mutual complementarity in Northeast Asia, a look at the current structure of sources of electricity in each country of Northeast Asia on the basis of power generated shows that each country depends on fossil fuel power plants for at least 60% of supply, with particularly pronounced degrees of dependency on fossil fuels in China and Mongolia, with 60% or more and 90% or more respectively. According to future forecasts announced by international agencies for 2030-2050, however, in 2030 it is projected that 30-50% of electricity generated in each country of Northeast Asia will be supplied from renewable energy. In April 2015, China's Energy Research Institute published a report indicating that 53% of energy by 2030 and 86% by 2050 could be supplied from renewables. Over the mid to long term, these countries will develop their own regional distinguishing features in terms of renewable energy sources, as seen in China's stress on wind power, Japan's on solar power, and Russia's on hydropower. Worthy of particular attention are Mongolia's vast potentials of renewables. In consideration of the continent's vast size, it is likely that economic efficiencies would arise in market trading as a result of differences in electricity prices and in peak demand as well. Already as of 2017 bilateral interconnections in

Northeast Asia had been achieved between Russia and China, Mongolia and Russia, and Mongolia and China, and trading in electricity was underway between these countries. Examples include Mongolia importing electricity from Russia and China to compensate for its lack of generating capacity and joint use of hydropower between neighboring countries in the Russian Far East and Northeast China.

With regard to a vision for interconnection in Northeast Asia, in 2002, the Korea Electrotechnology Research Institute, KERI, and the Russian Academy of Sciences, ESI, announced a proposed Northeast Asia Power System Integration Project, and in 2009 the Seoul office of the Hanns Seidel Foundation proposed the GOBITECH Initiative. Later, Renewable Energy Institute, established in 2011, proposed an Asia Super Grid based on renewable energy. The goal is to utilize renewable energy across Asia by connecting China, South Korea, Russia, and Japan via an international power grid using solar and wind power generated in Mongolia as the main power supply. Aside from these research institutions, companies that would serve in main roles promoting interconnection projects also are carrying out studies. Already in the first half of the 2000s Marubeni, Sumitomo Electric Industries, and Russia's Unified Energy System conducted a feasibility study on a Japan-Russia Power Bridge Project that would link a thermal power plant on Russian Far East Sakhalin Island to Niigata via Hokkaido, using undersea transmission lines. Since 2011, inspired in part by the Asia Super Grid vision proposed by Renewable Energy Institute, international power grid concept has been proposed mainly by power and transmission companies in Northeast Asia. In 2014, the Korea Electric Power Corporation and the Russian research institution Skoltech announced the Northeast Asia Super Grid plan, and then in 2016 they proposed a Northeast Asia Interconnection Vision. In 2015, the State Grid Corporation of China (SGCC), the world's largest power transmission company, announced its Global Energy Interconnection (GEI) vision. This is a vast vision calling for connecting the world through ultra high-voltage transmission systems with a proposed schedule that includes reaching a consensus by 2020, formation of grids on each continent by 2030, formation of intercontinental grids by 2040, and completion of grids on a global scale by 2050. The GEI vision stresses the goal of putting variable renewables such as solar and wind power to maximum use. In March 2016, the international nonprofit foundation Global Energy Interconnection Development and Cooperation Organization (GEIDCO) was established with the goal of realizing this GEI concept. It also is worth noting that the Russian government has formally made a specific proposal to the Japanese government on interconnections between the two countries.

The feasibility of an international power grid in Japan and related issues

Reasons for the lack of interconnections; Japan is an archipelago and the weakness of moves toward economic interaction in Northeast Asia due to the instability of the region's diplomatic relations. The state of Japan's existing electricity system is another reason. Although the power market reforms have moved in Japan in stages since 1995, compared to other countries the pace of the progress has been quite slow. Even now, unbundling has not yet been introduced, and market competition has failed to advance (only the Tokyo Electric Power Company Holdings, former Tokyo Electric Power Company, TEPCO, had achieved legal unbundling as of 2016). Since the accident at TEPCO's Fukushima Dai-ichi Nuclear Power Plant, full-fledged power-system reforms have been undertaking in Japan too. In April 2013 the Cabinet decided on a Policy on Electricity System Reform, in 2015 wide-area operations centers were established, in 2016 retail sales of electricity went to full competition, and progress is being made toward legal unbundling of power generation and transmission by 2020. In this way, it can be expected that once plans have been developed for construction of a grid based on a nationwide perspective and an appropriate mechanism developed for recovery of investment, then efficient expansion and operation, as in Europe, could be expected. At the same time, such a new business environment requires a very difficult challenge in management on the part of incumbent utilities. It is likely that regional

differences will appear in Japan's power supply structure, which has been unified until now, and each company will have its own stresses. Since retail sales of electricity and gas were liberalized, cooperation has been made across industries.

Factors related to the need for interconnections in Japan include, first of all, the fact that since electricity prices in Japan are very high by international standards, there would be a strong degree of inducement of cheaper electricity imports from overseas. Second, although the power supply structure does not have a high degree of complementarity at present, growth in renewables is particularly pronounced in Japan and China, and the Russian Far East and Mongolia have massive potential. Interconnection would accelerate the deployment of renewables and that would bring the flexibility with management of variable renewables. Third, Japan, China, and South Korea are very large electricity markets, and linking them would result in a market surpassing those of Europe and North America in size, leading to massive results in price adjustment and mutual complementarity. Fourth, lastly but not least, there is no arguing the fact that there is a need for greater international cooperation in Northeast Asia. For example, the Russian government has proposed a plan for practical interconnection, as mentioned above. There is a high likelihood that progress in interconnection would intensify interdependence and contribute to progress in diplomatic relations.

For Japan to build an international power grid and maximize its benefits, there is a need for further reforms to the domestic power system that would receive such electricity. First, there is a need to resolve the issues of the first-come-first-served basis contract of within and between regional grid connection and use, which has restrained grid capacity over the long term (while plans call for revising the concept of first-come-first-served in regional interconnection through adoption of implicit auctioning, a transitional period of 10 years would apply to existing power supplies). Since these domestic rules also could affect the possibility of connecting points in Japan in practical implementation of interconnection, there will be a need for changes to the Japan's domestic management with also taking into consideration international system designs.

While even now the day-ahead market accounts for a small percentage of transaction volume in Japan, in order for a large volume of electricity to be treaded in the day-ahead market based on economic efficiencies, including interconnection, the volume of transactions in the wholesale electricity market needs to expand. And, revenues from price differences between bidding areas, corresponding to congestion charges in Europe, have until now accumulated on wholesale electricity market as reserves, and are not necessarily being put to effective use. There is a need to review the way such revenues are used and to make it possible for transmission system operators to invest them in grid enhancements in Japan. As longer-term measures, drastic strengthening of the domestic grid system and progress on full-fledged reorganization and integration of the transmission business are needed.

With regard to what is needed in the legal system for Japan to implement interconnection, first of all international arrangements—a shared recognition regarding systems and cooperative relations—are essential. Regarding interconnection construction and ownership/operation, Japan as a nation whose land is surrounded entirely by water, interconnection necessarily involves undersea cables. The United Nations Convention on the Law of the Sea stipulates that each country may install undersea cables freely in extraterritorial waters. Since the waters between Japan and Russia and South Korea, anticipated as partners for installation of such cables, consist only of each country's exclusive economic zone, once agreements are concluded with these countries, there would be no particular problems with their installation under the treaty. Next, with regard to ownership and operation of interconnections, since the

legal systems vary by country regarding who owns and operates interconnections, there is a need for a shared recognition among related countries, at a governmental level. Also, there is a need to consider matters such as how to set transmission fees of interconnection, distribution of revenues and maintenance costs, whether to restrict for-profit use, and how to allocate interconnection capacity. In addition, as a prerequisite there is a need for cooperative relations regarding connection to the domestic grids. Furthermore, harmonization of the framework for electricity transactions is needed. It is conceivable that electricity transactions could take the forms of both direct dealing and market transactions. Lastly, it probably would be necessary to establish means of dispute resolution as well.

In starting up interconnections with other countries, there have been many cases where agreements were concluded under the leadership of national governments or governmental bodies. Since Japan's Electricity Utilities Industry Law does not envision interconnections, there is a high likelihood for necessity of consideration on legal and regulatory reforms as well. When considering international grid connections as having the same characteristics as regional grid connections, it is conceivable that transmission licenses under current law could be used. The Telecommunications Business Act calls for licensing of telecommunication enterprises regardless of whether they are international or domestic. Alternatively, it also is possible that new licenses could be established especially for interconnections. Among other countries, there are examples of both those that specify explicitly the differences between international transmission licenses and standard transmission licenses and those that do not under the law. Although the Electricity Utilities Industry Law has no specific provisions concerning installation of undersea transmission lines, the Fishery Act does have provisions concerning installation of undersea transmission cables, and since in fact multiple undersea transmission cables for telecommunication have been installed in the seas of Japan, it is likely that there would be no particular impediments to their installation for electricity. Also needed are steps such as enabling participation in electricity markets from overseas and provisions on tariffs on trade in electricity. While as seen here there are many legal and systematic matters, in consideration of the fact that progress has been made on interconnections through agreements and coordinations among countries with different legal systems overseas, it is unlikely that doing so would involve any major problems.

There are no absolute reasons that it would be impossible to construct and operate international power grids in Northeast Asia including Japan. The fact that other countries of Northeast Asia, as well as their transmission and power companies, have made proposals for international power grids connecting this region should be given serious consideration. The time has come for us to break through the preconceived notion that as an island nation an international power grid would be impractical in Japan and to recognize that such a network is essential for both the Japan of today and other countries in Asia and could, ultimately, contribute to resolving global energy issues. In order to realize international transmission of electricity, the government must have a firm commitment to the realization and begin formal discussions with other countries' governments.

In light of these topics, it will be essential further to sort out various issues and risks by quantitatively considering costs and benefits while envisioning practical construction plans for interconnection. In the mean time, the policy proposals needed by Japan in order to realize these goals must be considered in more practical terms. Also, the relations with Asia as a whole should be considered, referring to existing cases such as those of North America and Southeast Asia.