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Northeast Asia Interconnection and Energy Security

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Abstract: ***The Northeast Asian countries has experienced the world's highest economic growth rate in last two decades, and the resulting income rise, together with a growing population, has led to a surge in energy demand that is expected to continue to be the most dynamic economics of any country in the world, for at least in coming two decades. While high economic growth in the Northeast Asian countries will inevitably result in drastic increase of energy demand in the region. At the center of this expectation lies the prospect that China will rise as the most promising economy in the coming years. In the second, heavy dependency on coal and oil in the region points to its vulnerability to environmental issues. At Paris meeting it was clearly declared that international efforts for environmental preservation are likely to limit the use of fossil fuels in one way or another. This means that the countries in Northeast Asia could experience a serious problem in their efforts toward economic prosperity due to high environmental externality costs of energy, unless they convert to more environmentally-friendly renewable energy based energy supply systems. Growing concerns for environmental deterioration and climate change have caused the Northeast Asian countries to focus on increased use of renewable energy and on the possibility to improve energy supply through energy market integration and energy system interconnection between the countries in the Northeast Asian region. Northeast Asian countries are seeking to improve energy market efficiency and secure cost-effective energy supply through energy market integration and system interconnection. Advanced technologies of grid network and interconnection solutions of renewable energy, specially focusing on the high voltage DC transmission (HVDC) system and renewable energy technologies will be discussed in this paper. As part of the Asian Development Bank (ADB) country operations business plan for 2015, the Government of Mongolia sought ADB technical assistance (TA) to prepare a strategy for Northeast Asia power system interconnection (NAPSI) using Mongolia's abundant solar and wind energy resources. The preliminary results of the study on possible options for interconnection of the power system in Northeast Asia and Road map for development of Asian Super grid by utilizing Mongolia's vast renewable energy resources are described in this paper.***

Keywords: Northeast Asia, Mongolia, Asian Super grid, interconnection, Mongolia's vast renewable energy resources

1. Introduction

The protection of global climate and conservation of the valuable resources and achieving sustainable global development-these are the key challenges that world is facing today. As a demand for energy is increasing rapidly, the many countries of the world faces not only energy security challenges, but also faces serious environmental problems such as global warming and depletion of traditional fossil fuels.

The Northeast Asian countries has experienced the world's highest economic growth rate in last two decades, and the resulting income rise, together with a growing population, has led to a surge in energy demand that is expected to continue to be the most dynamic economics of any country in the world, for at least in coming two decades [Asia's Dynamic Economies Continue to Lead Global Growth, May 9, 2017, Regional economic outlook. Asia Pacific: Good times, uncertain times, a time to prepare. IMF, 2018 https://www.imf.org/en/News/Articles/2017/05/08/NA050917-Asia-Dynamic-Economies-Continue-to-Lead-Global-Growth]. While high economic growth in the Northeast Asian countries will inevitably result in drastic increase of energy demand in the region. Global energy demand is expected to increase more than 50% by 2040, with largest increase in Asia, particularly in Northeast Asia [International Energy Outlook 2017, U.S. Energy Information Administration, 2017] as it shown in the Fig. 1.

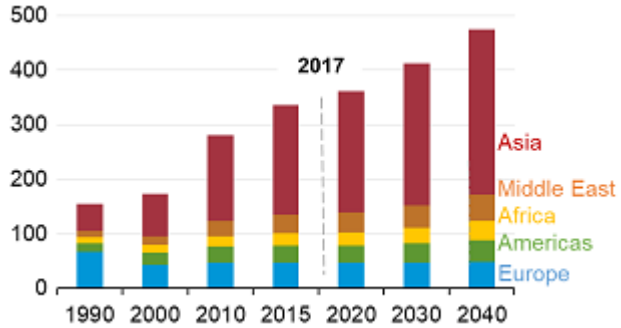

Figure 1: Energy consumption by region, 1990-2040 (Asia has biggest consumption)

At the center of this expectation lies the prospect that China will rise as the most promising economy in the coming years. In the second, heavy dependency on coal and oil in the region points to its vulnerability to environmental issues. At Paris meeting it was clearly declared that international efforts for environmental preservation are likely to limit the use of fossil fuels in one way or another. This means that the countries in Northeast Asia could experience a serious problem in their efforts toward economic prosperity due to high environmental externality costs of energy, unless they convert to more environmentally-friendly renewable energy based energy supply systems. Growing concerns for environmental deterioration and climate change have caused the Northeast Asian countries to focus on increased use of renewable energy and on the possibility to improve energy supply through energy market integration. Theoretically, it can be considered that an energy system is sustainable for long term period if more than 2/3 of the energy demand covered by renewable energy sources [World Energy

Resources, World Energy Council, 2016]. Therefore, it is expected that renewable energy will play dominating part of the future energy supply in the Northeast Asian countries.

Renewable energy sources are, by definition, inexhaustible. However, some renewable energy sources may fluctuate dramatically over the different time periods. For some of the renewable energy sources, the fluctuations are quite predictable but for others such as solar and wind power sources the fluctuations are non-controllable and non-predictable since it is difficult to predict their intensities. The variability of the power generation caused by the use of renewable energy sources such as solar and wind power systems are going to be bigger challenges as the contribution of renewables to transmission grid rises to a substantial level. In the other hand, apart from biomass and hydropower, renewable energy sources are not possible to be stored naturally. Therefore in order to avoid intermittency of solar and wind power sources, large capacity energy storages have to be developed as required. One of the most promising ways to overcome these challenges caused by the use of renewable energy sources such as solar and wind power systems is an integration of renewable energy power sources into high capacity transmission grid called "Super grid" [Supergrid, Wikipedia, https://en.wikipedia.org/wiki/Super_grid]. The "Supergrid" can be defined as a system of high capacity transmission grid designed to transfer large amounts of electricity over the long distances. The High Voltage Direct Current (HVDC) transmission is now becoming a key technology to transfer massive amounts of energy over long distances while integrating an increasing amount of renewable energy into the regional energy system.

Landscape of Renewable energy development of Mongolia

Mongolia is located between the Russian Federation and China and with only 3.3 million inhabitants in the massive 1.5 million sq.km land. Mongolia is served by a integrated energy system that consists of five energy subsystems, the Central Energy System (CES), the Western Energy System (WES), the Altai-Uliastai Energy System (AUES), and the Eastern Energy System (EES) [Ministry of Energy of Mongolia, 2017] as it shown in Fig. 2 [2].

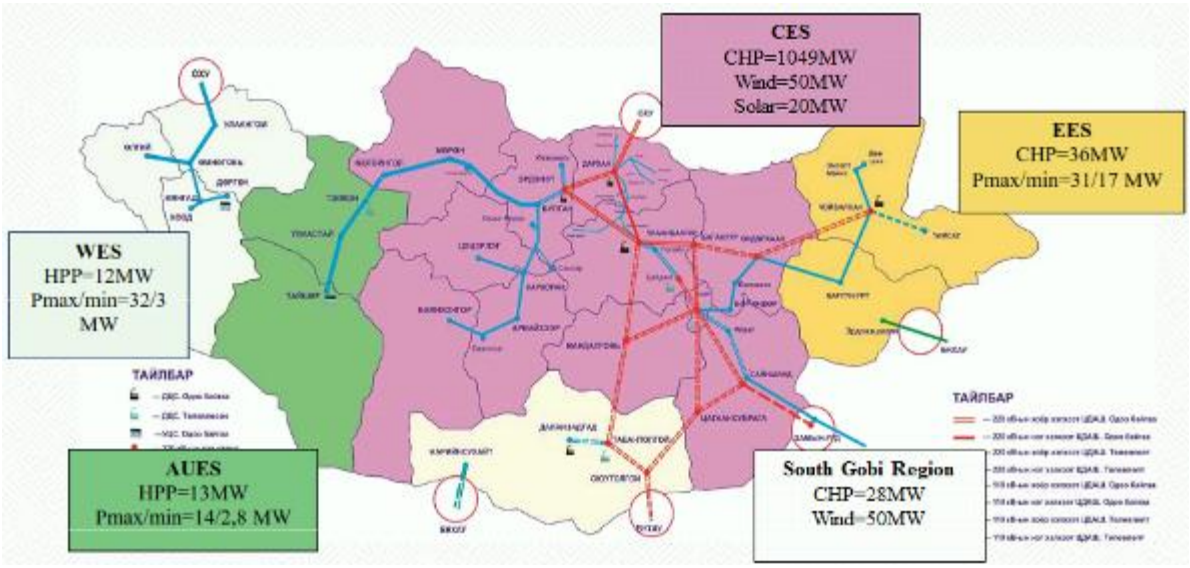

Figure 2: Integrated Power Energy System of Mongolia

The current installed power capacity in Mongolia has reached approximately 1104MW of generation capacity, with coal providing majority of electricity generation and imports from Russia meeting any remaining demand. Approximately 85% of the total electricity generated domestically results from coal-fired CHPs, ~7% from diesel systems, ~5% from wind farms, ~2% from hydropower plants and the remaining ~1% is supplied by solar power plant and some small renewable energy power sources [Ministry of Energy of Mongolia, 2017]. Currently, according to the Ministry of Energy, 79.42% of the total energy consumption of Mongolia is produced domestically and 20.58% was imported from Russia and to a very lesser extent from China [Ministry of Energy of Mongolia, 2017]. Mongolia's power demand is growing rapidly (around **6–8%** annually) per year as the economy grows. The ADB-assisted energy sector master plan study concludes that peak demand was forecast to rise from ~1104MW in 2017 to ~1.9GW in 2020 study [Mongolian Energy sector development Master plan-Revision (TA No 7619 MON), Final Report, 2015,Mongolia]. To meet this demand there are several fossil fuel and renewable energy projects totalling over 0.9GW of capacity in planning stage. As regards renewable energy capacity development, the government of Mongolia has mandated that power from renewables reaches 20% of energy demand by 2020 and 30% by 2030. Current renewable energy capacity stands at only 158MW with the vast majority from wind and small hydro plants [Namjil Enebish, Christian Breyer and Dimitrii Bogdanov, Optoins for Mongolia in energy transition to 1005 Renewables, AFORE2018, 2018, Ulaanbaatar, Mongolia] (Fig.3).

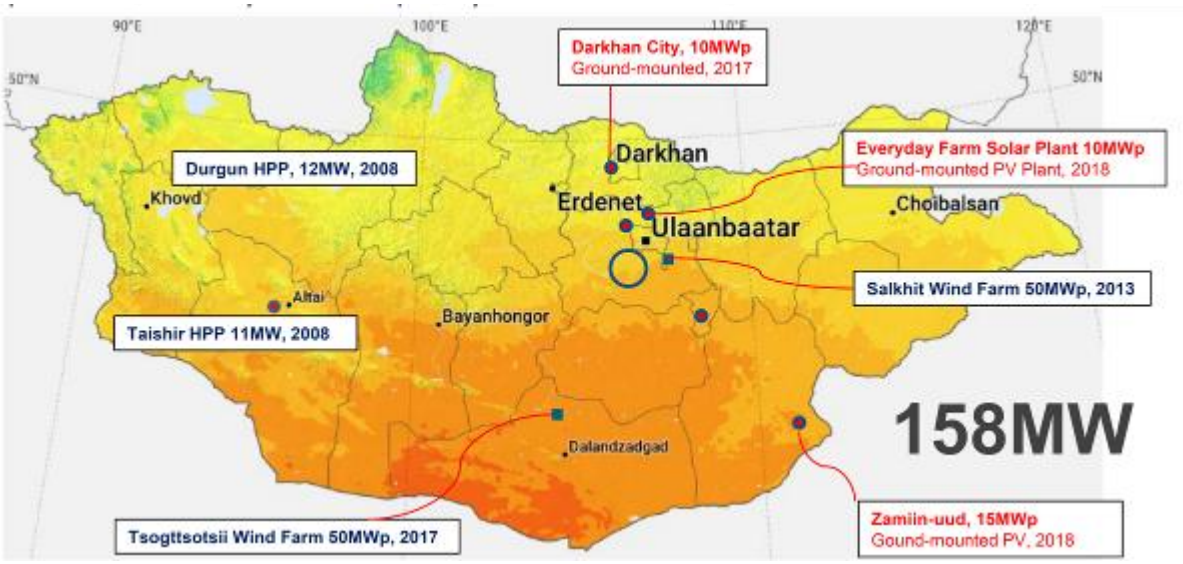

Figure 3: Current capacity of renewable energy development of Mongolia

In 2008-2009 there was introduced two small hydropower plants, namely Durgun hydropower plant (12MW) and Taishir hydropower plant (11MW). Later in 2013 first 50MW wind farm was installed in Salkhit valley of Tuv aimag by private investment of Newcom, Mongolian company and in 2016 -2018 two more wind power projects, Tsogttsetsii 50MW wind farm and Sainshand 55MW has been successfully implemented. One of them, Tsogttsetsii 50MW wind farm, is in operation since 2016 and another one, Sainshand 55MW wind farm is going to be commissioned soon, within 2018 (Figure 4). Besides that there are three utility scale solar power plants, Darkhan 10MW Photovoltaic power plant, Everyday 12MW PV plant and Zamiin-uud 15MW Photovoltaic power plants were successfully developed during the 2016-2018 and two more projects, Sumber 10MW Photovoltaic power plant, Khoshogt valley 15MW Photovoltaic power plant are under construction and these plants are planned to be commissioned within this year. As it shown in Figure 4, total installed capacity of the renewable energy power generation will be reaching 243MW by the end of 2019 [Namjil Enebish, Christian Breyer and Dimitrii Bogdanov, Optoins for Mongolia in energy transition to 1005 Renewables, AFORE2018, 2018, Ulaanbaatar, Mongolia].

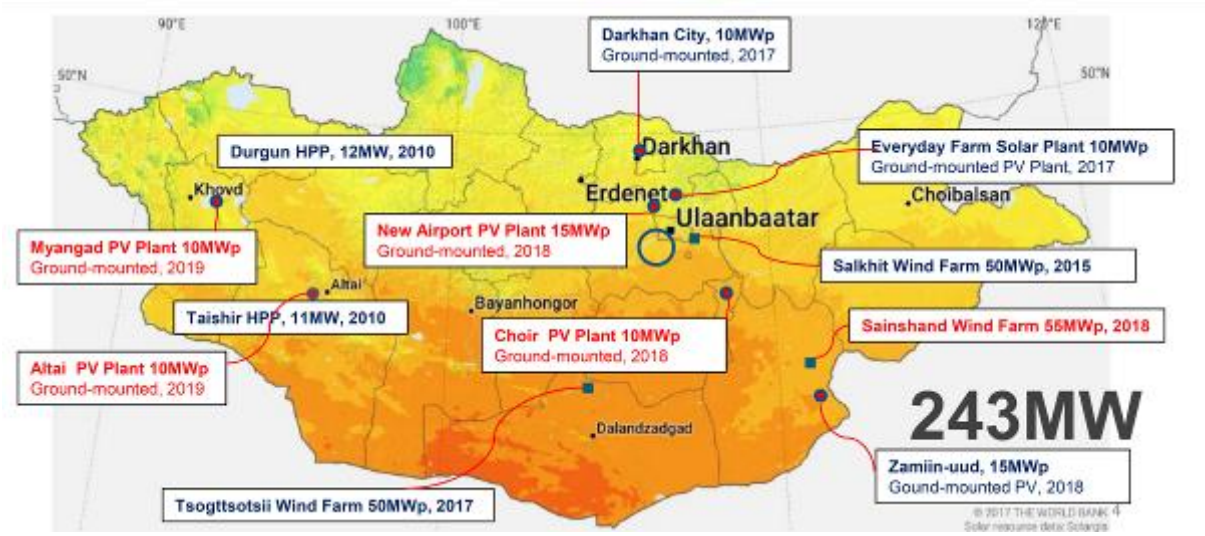

Figure 4: Landscape of renewable energy development for period of 2018-2019

In 2020-2025 two more hydropower projects Egiin Hydropower plant (315MW) plant and Erdeneburen hydropower plant (64MW) are planned to be implemented as it is indicated in the Fig. 4. Besides that there are several utility scale mega solar and wind power plants are under development. It means renewable energy capacity can reach over 622MW in coming years if planned capacity will be introduced by 2025 [Namjil Enebish, Christian Breyer and Dimitrii Bogdanov, Optoins for Mongolia in energy transition to 1005 Renewables, AFORE2018, 2018, Ulaanbaatar, Mongolia].

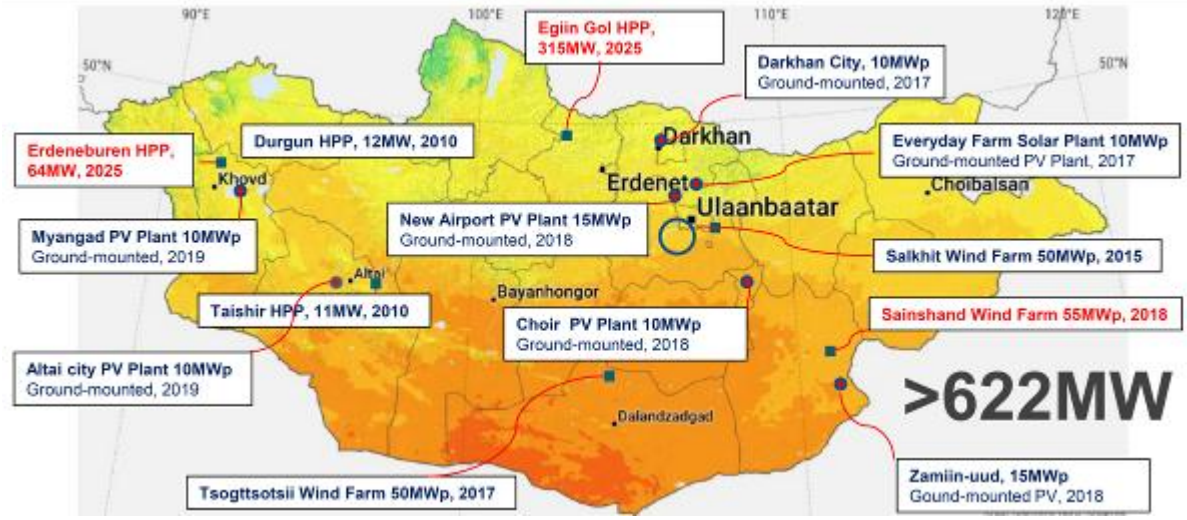

Figure 4: Planned renewable energy projects to be implemented for period of 2020-2025

The increasing share of renewable energy sources, such as photovoltaic power plants, wind farms integrated into conventional power systems can address problems related to fossil fuel deficiency, environmental pollution and reduction of greenhouse gas emissions. However, the integration of high capacity of solar and wind power system may influence the overall dynamics of the power system and may cause certain technical effects because the network design initially does not consider the integration of variable renewable energy sources. These technical issues related to the rapid output fluctuations of renewable energy power system may influence on the operation and control, power quality, and power system stability (such as grid instability, curtailment for power producers). The variability of the power generation caused by the intermittent nature of the renewable energy sources such as solar and wind power systems are biggest challenge when contribution of renewables to transmission grid rises to very substantial level. One of the most efficient ways to overcome this challenge and to achieve the ambitious goals of increasing the share of renewable energy is to use high capacity transmission grids, called "Super grids" designed to transfer large amounts of power over the long distances with lower losses to the load centers with high energy demand.

To move toward a cleaner renewable energy based energy system, we must improve our nation's electrical grid, as well as construct the transmission infrastructure needed to connect renewable energy facilities to neighboring countries and regions with high energy demand. For this reason, Gobitec initiative for Northeast Asia was initiated in December 2010 for the first time [1]. Gobitec concept is to produce clean energy from vast renewable energy sources in the Gobi Desert of Mongolia and deliver the produced energy to high-demand power places via the High-Voltage Direct Current (HVDC) transmission lines, which will connect Russia, Mongolia, China, South Korea and Japan.

The Gobitec initiative for Northeast Asia follows the model of DESERTEC - a EU companies developed mega-project that intends to deploy renewable energy plants in the Middle East and North Africa to meet domestic electricity demand and to export surplus electricity to Europe[2]. Later, just after the Great Eastern Earthquake of March 2011, led to the Fukushima Daiichi disaster and closed down the country's nuclear industry, Masayoshi Son, the founder and chief executive of Japanese telecoms giant SoftBank, has initiated an idea of Asian Supergrid concept[3]. Masayoshi Son believes the super grid would solve one of Japan's most pressing strategic problems: how to provide energy security for a country that has high demand but declining coal reserves, limited space for onshore renewables, and faltering appetite for nuclear.

The supergrid based on High-Voltage Direct Current (HVDC) technology is most appropriate technology for the establishment of the regional and global electricity network connecting long distances. There are a number of global and regional network concepts has been proposed including "Desertec" in the Mediterranean region to use solar energy use of the Sahara desert[4] and a "Seatec" as the North Seas Countries Grid Initiative to use offshore wind capacity at North sea region [Wilfried Breuer, Siemens, DESERTEC, SEATEC and Super Grid Prospects of Grid Development, GRIDS 2010: The backbone of Europe's energy future, 23 - 24 November 2010, Berliner Congress Center, Berlin, Germany] and 'Gobitec' in Northeast Asia to use vast renewable energy potential of the Gobi desert to power Northeast Asia [N. Enebish, Concentrated Solar Power as a feasible part of the European and Asian energy mix? From Desertec EUMENA to Gobitec, A GREEN FUTURE: Asia and Europe Growing Sustainably, Summary of Proceedings, Asia-Europe Environment Forum Conference 2010, 1-3 September , 2010, Munich, Germany]. IEA PVPS Task8 group [Kosuke Kurokawa, et al., Energy from the Desert: Feasibility of Very Large Scale Photovoltaic power Generation (VLS-PV) Systems, James and James, 2003] has

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[2] Desertec, https://en.wikipedia.org/wiki/Desertec

[3] Masayoshi Son Founder and Chairperson Japan Renewable Energy Foundatition , Opening Remarks on International Symposium "REvision 2012 New Renewable Direction for Japan" March 9, 2012

[4] Desertec, http://www.desertec.org/

proposed a concept of Very Large Scale Photovoltaic Power Generation system (VLS-PV) to be interconnected with supergrid in the Northeast Asia as below in Fig 6.

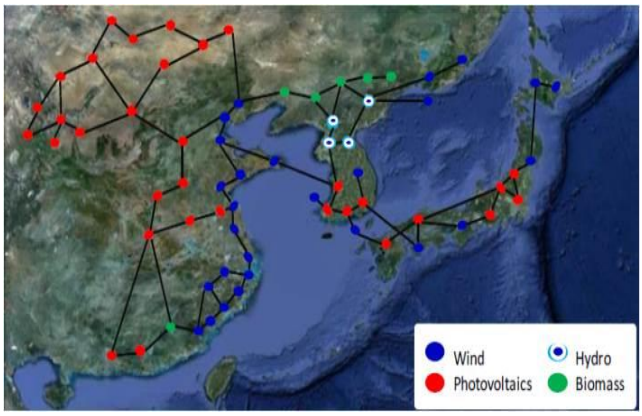

Figure 6: A concept of VLS-PV based Super-Grid in the Northeast Asia proposed by IEA PVPS Task 8 Group

A vision of the Gobitec and Asian Supergrid (ASG) initiatives are very ambitious and it's realization may significantly improve not only energy integration in the region but also can bring a number of economic, social, environmental and political benefits to the all countries of the Northeast Asian region[5]. It has a full potential to meet the challenges of the energy supply for Northeast Asia and shift to renewable energy supply at larger scale[6]. Recent technological advances of HVDC technology has made HVDC transmission as a crucial element for an efficient, smart power system of the future. It is expected that of HVDC system may have an even greater role to play in increasing of high share of renewable energy to the grid and developing cross-border electricity trade. Large scale wind farms and Mega and Gigawatt-scale solar power plants in Gobi desert area could be could be successfully connected together to the regional supergrid networks. While the potential benefits of such regional energy integration are quite clear and HVDC transmission technology is already proven commercial technology, which can be successfully applied for the interconnection of the regional electricity network, however, there are numerous barriers to overcome in order to achieve it in practice[7].

In realization of the Gobitec and Asian Supergrid initiatives, the governments of the participating countries political institutions should take a pioneering role. The high level Government commitment for long term cooperation between participating countries, agreement for establishment of the regional electricity network would be first significant step towards to realize such big project as Gobitec and ASG initiatives. The governments in the region need to demonstrate their strong political commitment to support such regional energy projects. In order to gain the confidence of the private sector and the international financing community to provide investment decisions it is necessary to develop a clear, transparent and stable legal and regulatory framework as well as regional and national transmission planning need to be developed and agreed between all stakeholders.

Potential of renewable energy of the North East Asia

Geographically, the Gobi Desert is located in the boundaries of Mongolia and China. Gobi desert area of Mongolia and China has tremendous amounts of renewable resources, especially solar and wind energy. Since 1999 under umbrella of IEA PVPS Task 8, a number of researches have been carried out comprehensive studies on Very Large Scale Photovoltaic Power Generation systems in world deserts, including Gobi desert of Mongolia[8].

According to the IEA PVPS Task 8 study 40% Gobi deserts landmass is most suitable for construction of the VLSPV[9]. The theoretical potential of solar energy of the Gobi desert is enormous - far beyond what the world could ever require. Gobi desert has also large amount of wind resources especially in southern part of Mongolia, as well as very high wind potential in coastal area of East China Sea. The average wind energy density of Mongolia is 7MW/km^2 and solar energy density is 66MW/km^2. For example, the wind energy density of class I area in the Gobi Desert is higher than 0.4~0.6 kW/m^2 based on average wind speed 7.1~8.1 m/s at 30 m height[10]. This is the equivalent density of 400~600MW/km^2. There are also huge potential of hydropower resources within the region (eastern Siberia, Russian Far East, Central and south China, as well as some part of Japan and Korea). Therefore, it can be concluded that solar and wind resources of the Gobi desert is most promising renewable energy resources, which are sufficient to power all Northeast Asia several times.

Needs of cooperation for supergrid in the North East Asia

The Asia in general and Northeast Asia in particular have experienced highest rate of economic growth in the past. Northeast Asia is becoming one of the fast growing world leading economies. Due to high economic growth, the Northeast Asia has been one of the fastest growing energy markets over the past 30 years. It is expected that this trend

[5] Keiichi Komoto, et al., Energy from the Desert: Very Large Scale Photovoltaic Systems: Socioeconomic, Financial, Technical and Environmental Aspects, Earthscan, 2009
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will persist in the foreseeable future at a higher rate of energy consumption than in other parts of the world. Therefore, the energy supply infrastructure in the Northeast Asian sub-region have to be changed continuously in response to issues such as increasing demand, resource availability, environmental concerns, changing technology and the need for regulatory reform, and sector restructuring. On the other hand, Northeast Asian countries, namely Korea, Japan are highly dependent on external energy supplies, especially oil and gas. Korea imports 96% of primary energy from abroad, 82% of its oil imports are purchased from the Middle East[11]. Currently Japan's energy self-sufficiency, excluding nuclear power, is about 4.9%[12]. Therefore, it can be concluded that compared to other Northeast Asia countries, South Korea, Japan are more vulnerable in terms of energy security as they have almost no natural resources both countries are highly energy dependent. China and Mongolia can be added to the category of vulnerability in terms of shortage of energy supply. Therefore, all Northeast Asian countries are vulnerable not only to the energy security but also quite vulnerable to climate change impact too. To narrow the gap between rising energy demand and deficit of energy supply, it is necessary to deepen energy cooperation between Northeast Asian countries to satisfy their increasing electricity demands with a safe and clean renewable energy than that provided by the conventional or nuclear power plants. Besides that, the distribution of and demand for the fuel resources for electricity generation in Northeast Asia do not coincide geographically. At the same time each country encounters the different problems of energy shortage and even energy security. These factors clearly show that there is an urgent need for developing of transnational electricity exchange in this sub-region.

Energy cooperation itself not only economic cooperation, it is also more political and environmental cooperation. Therefore energy integration in Northeast Asia is critical factor in order to keep fast economic growth in the sub-region continuously[13]. To maximize the benefit from energy integration to the economies for each country, as it was mentioned above a strong high level multilateral political cooperation is needed. One of the key cooperation agenda can be development of joint energy infrastructure in Northeast Asia. Energy integration among Northeast Asian countries can create a large market and expansion of economic potential for all participating nations and may contribute in political peace and security.

Energy integration with introduction of transnational supergrid will require:

- To have a joint energy cooperation strategy in which the participating countries can align their targets and harmonize them with national renewable energy strategies.
- To have an agreement in eliminating physical, trade and regulatory barriers to ensure beneficial electricity market in Northeast Asia.
- To have legal certainty for the participating countries, investors and other stakeholders.
- To develop a harmonized set of trade and transit rules to reduce investment risks and create a joint platform of electricity exchange.
- To have an agreement that benefits from the cross-border electricity exchange are concentrated not only for a few countries but are distributed among all participants.

By observing emerging efforts by Northeast Asian countries to develop a renewable energy, it can be concluded that Northeast Asia are on the way to shift for a renewable energy future, but actual movements are in different stages of development. In the recent renewable energy policies of China, it can be find the most important and flexible industrial policies to support and promote renewable energy development. China has not only an effective and favorable government policies to support the development of renewables and HVDC grid, but also their experience of building large scale renewable energy projects, constructing high capacity long-distance HVDC power lines, and utilizing advanced HVDC technology are very important lessons for the Northeast Asian countries. These can serve as energy integration model for the region in the future. A regional HVDC supergrid connecting Northeast Asian countries should offer following opportunities:

- It could enable mutual economic benefit through renewable energy development and infrastructure construction and cost-effective energy supply in the participating countries in Northeast Asia.
- It could strengthen energy supply security through diversification of energy supply through renewable energy development.
- It could build the basis to increase share of renewable energy and help Northeast Asian countries to contribute significantly in greenhouse gas emission reductions
- It will help Northeast Asian countries to meet their increasing electricity demand with a safe and clean renewable energy power sources than that can be provided by the conventional or nuclear power.
- It will build investor's confidence in increasing investment in renewable energy, which can lead to shifting investment to renewable energy development.
- After review of the existing experiences of renewable energy development and construction HVDC supergrid project in the world, the following recommendations can be drawn in relation to the implementation of Gobitec and ASG in Northeast Asia:
- The technology of HVDC supergrid transmission line, as well as technology and construction of the VLSPV plant and large capacity wind farms are now becoming very cost effective and mature commercial technology. Therefore, it can be concluded that the implementation of the Gobitec and ASG project is feasible from the technological point of view.
- Construction of the regional HVDC supergrid transmission line, as well as increasing share of renewable energy in the region will lead to further decrease a cost of electricity as because renewable energy potential is

[11] Country Analysis Brief: South Korea , U.S. Energy Information Administration, July 2018
http://www.ieee.es/Galerias/fichero/OtrasPublicaciones/Internacional/2018/EIA_south_korea_20jul2018.pdf
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abundant especially in the Gobi Desert and cost of solar, wind technology is decreasing significantly.

- The governments in the region need to demonstrate their high level government commitment risk reduction for the development of the Gobitec and ASG project, which is key factor to gain the confidence of the private sector and international organizations and a multilateral development banks to support major investment decisions for the actual implementation Gobitec and ASG project.
- As because the implementation of the Gobitec and ASG project is capital intensive, an improved investment climate is necessary.
- As because the Gobitec and ASG project is transnational international project, a clear, transparent, stable legal framework for long-term energy cooperation based on mutual benefits for energy-producing, energy-consuming as well as transit countries have to be developed.
- As because of Gobitec and ASG project is regional transnational project which uses high capacity transmission lines passing several countries, regional stability and peace in the region have to be secured.
- As because the Gobitec and ASG project may deliver a number of economic, social and environmental benefits to participating countries, such as transfer of high technology, job creation, poverty alleviation and a reduction of carbon dioxide (CO_2) emissions, strong political and financial support from all countries is needed to support implementation of this project.
- As because the implementation of the Gobitec and ASG project will apply the latest achievement of high technology the intellectual property rights have to be insured accordingly.
- As because the Gobitec and ASG project can contribute to regional development of renewable energy strong support of international organizations and a multilateral development banks, including ADB, World Bank, ESCAP, IRENA and The Asian Infrastructure Investment Bank (AIIB) is needed.

2. Conclusion

One of the key solutions to overcome the problem of increasing demand of energy, protection of global climate and conservation of the valuable finite resources is significant increase the share of renewable energy among total primary energy supply. Renewable energy now provides around one-fifth of the world's electricity and it is becoming an important part of today's energy supply.

The abundant solar, wind resources of the Gobi desert in combination with environment-friendly hydropower reserves of the Russian Far East could become the key source of energy for the countries in the Northeast Asian region, and would lessen the region's heavy dependence on fossil fuel import.

Observing emerging efforts that some countries having during the last years for the development a renewable energy it can be concluded that world is moving forward to the shift for a renewable energy future, although actual movements are in different stages of development.

The variability of the power generation caused by the use of renewable energy sources such as solar and wind power systems may cause some challenges when the contribution of renewables to transmission grid rises to a substantial level. One of the most efficient ways to overcome these challenges is an integration of renewable energy power sources into high capacity HVDC transmission supergrid for transferring massive amounts of energy over long distances.

The supergrid, in combination with advances in HVDC grid technology will provide an effective solution to emerging problems associated with renewable energy integration. The ultrahigh voltage supergrid is becoming a global trend now and the technology of HVDC and UHVDC as well as technology of the VLSPV plants and wind farm is now becoming cost effective, technically proven commercial technologies capable to be applied for any regional energy infrastructure projects such as the ASG in Northeast Asia.

The development of renewable energy integration fosters HVDC applications worldwide and one of the key drivers for the HVDC development in worldwide is necessity of integration of high capacity renewable energy power sources. China has already developed several long distance HVDC transmission lines successfully and currently it is accelerating it's UHVDC construction and becoming biggest manufacturing base of all kinds of HVDC supergrid system components.

Due to high economic growth in the past, the Northeast Asia is becoming one of the fastest growing energy markets and it is expected that this trend will persist in the foreseeable future at a higher rate of energy consumption than in other parts of the world. To narrow the gap between rising energy demand and deficit of energy supply, it is necessary to deepen energy cooperation between Northeast Asian countries to satisfy their increasing electricity demands with a safe and clean renewable energy than that provided by the conventional or nuclear power plants. The energy integration in Northeast Asia is critical factor in order to keep fast economic growth in the region continuously.

Energy cooperation itself not only economic cooperation, it is also more political and environmental cooperation. One of the key cooperation agenda can be development of joint energy infrastructure in Northeast Asia, such as the Gobitec and ASG initiatives, which can enable to increase share of renewable energies. Successful implementation Gobitec and ASG into practices will require a high level government commitment and intergovernmental negotiations to eliminate physical, trade and regulatory barriers in order to ensure beneficial electricity market in Northeast Asia. High level intergovernmental agreement would be an important first step towards to meeting goals of the ASG – to build regional electricity network for Northeast Asia.

Finally, as Northeast Asian countries have different times of peak electricity demand due to time difference and seasonal variation of meteorological conditions (in Mongolia and China demand peaks appears during winter times, while in Japan, Korea the demand peak occurs in the summer) regional HVDC supergrid transmission line may help in power balancing of the supply and can smooth energy

balance, which may enable all countries to share effectively generated power and storage facilities, allowing for more economic operation of the power sector in each countries as whole.

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