GOBITEC AND ASIAN SUPER GRID FOR RENEWABLE ENERGIES IN NORTHEAST ASIA

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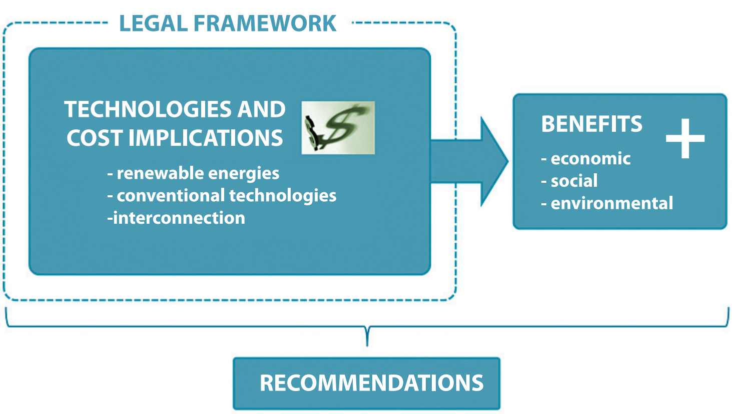
EXECUTIVE SUMMARY:
Promoting Gobitec
and Asian Super Grid (ASG) Initiative

The Gobitec concept represents the idea of producing clean energy from renewable energy sources in the Gobi Desert and to deliver the produced energy to regions with a high demand of electric energy. The delivery of the energy produced is planned to be using power corridors: the planned Asian Super Grid (ASG), connecting Russia, Mongolia, China, South Korea and Japan. The project is similar to the DESERTEC project which aims to deploy renewable energy plants in the Middle East and North African countries to meet domestic electricity demand and to export surplus electricity to Europe. The DESERTEC project is backed by an industrial consortium consisting of reinsurance, technology and other companies.

Figure 1-1: Gobitec project

This study has the objective to present a first analysis of the technological and legal challenges that derive from such a megaproject. Therefore, the general questions to be answered are: What are the cost implications? What is the overall legal framework and how should it be changed to support the Gobitec vision?

Figure 1-2: Contents of the Gobitec study



The study is structured into five chapters. In this first chapter, an executive summary will be given on the Gobitec perspective. The second chapter presents in detail an initial estimation of the technology and cost implications. It also focuses on the important question of the implementation and cost of an ASG, which is necessary to transport electricity generated in the Gobi Desert to the demand centres in the different countries. The third chapter covers the important topic of the legal framework. The main focus is the assessment of trade legislation. This chapter also describes the different and already existing cooperation platforms, which could be used to implement the Gobitec and ASG idea. Furthermore, it gives recommendations and ideas in relation to financial issues and the implementation of legal matters. The fourth chapter gives an overview of the benefits of a possible Gobitec project: Economic, social and environmental benefits for Mongolia and the other ASG countries will be regarded. The last chapter summarises the conclusions drawn from the previous chapters.

ASG interconnection target system

Key message:

The ASG aims to interconnect strategic countries in Northeast Asia (NEA) with electricity generation areas in the Gobi Desert.

The ASG represents the strategy of connecting locations of high energy demand with regions of large renewable energy potential. Therefore, the proposed grid connects renewable energy sources in the Gobi Desert with Irkutsk in the North, incorporating hydropower electricity in the system. It is also connected to the locations of demand in Shanghai and Seoul in the South as well as Tokyo in the East of the ASG region.

Figure 1-3: Possible course of the ASG

A super grid implies technical and political challenges because of the large geographical extent. The advantages, however, are that demand and supply can be balanced more easily because regional differences are levelled out by the size of the system. Also, energy conversion technologies can focus on places of high energy output and on the available land area, while the grid provides the connection to the places where the electricity is demanded. The ASG will allow for the free exchange of electricity between countries in NEA, thus providing large economic, social and environmental benefits.

Technologies and cost implications

Key message:

The objective is to connect Irkutsk in the North, Shanghai and Seoul in the South and Tokyo in the East of the ASG region with high voltage direct current (HVDC) transmission lines. Wind and solar photovoltaic (PV) systems are the dominating technologies deployed.

The technologies and cost implications of the Gobitec project are analysed in Chapter 2 of this study. In order to ensure an effective flow of electricity generated in the Gobitec project, the transmission system should be designed as follows: Cross-border transmission lines connect the Gobi Desert with Irkutsk in the North, Shanghai and Seoul in the South and Tokyo in the East of the ASG region. Countries will be responsible for their local interconnection lines from the ASG trunk line and to their own power system connection point. Because of the high potential for renewable energy technologies in the Gobi Desert of Mongolia and large amounts of hydropower potential in Russia, these two countries will be exporting renewable energy, while all other countries will import energy from the Gobitec project.

Figure 1-4: 50 MW Salkhit wind farm, Mongolia

China has the largest installed power plant capacity among the ASG countries, dominated by coal and hydroelectric power. Because of a high economic growth rate, electricity demand is expected to continue to increase greatly. For the other ASG countries, electricity demand is expected to saturate in the long term. For all countries, a somewhat stable composition of generation capacity is forecasted, except for China where the amount of gas and nuclear energy will be increased to provide additional electricity. Because of the Fukushima Nuclear Accident of March 2011, the installed capacity of nuclear power plants in Japan is expected to decrease.

Because of the extensive electricity transport distances in the ASG project, the use of HVDC transmission lines is strongly recommended. High voltage direct current can be distinguished by the type of system interconnection, which can be either point-to-point DC (PTP-DC) or back-to-back DC (BTB-DC). For connecting long distances, PTP-DC is more appropriate. High voltage direct current can also be distinguished by the type of converter, which can be a voltage source converter or a current source converter. It is not yet clear which technology is more appropriate for the ASG project. The Gobitec transmission corridor should be operated at a voltage of more than 1000 kV in order to keep transmission losses low.

The generation costs of solar and wind farms for Gobitec were calculated. This was done on the basis of costs for construction, the operation and maintenance costs, as well as the costs of collecting, transmitting and supplying electricity. The cost was calculated for differing capacity factors for solar and wind energy.

Legal frameworks

Key message:

A legal framework, Energy Charter Treaty (ECT), is necessary for the Gobitec and ASG initiatives, ensuring a positive investment climate, reliable transit regime and protection of property rights. Furthermore, electricity exchange and transmission regulations must be developed and deployed.

Foreign direct investment (FDI) has the potential to generate employment, raise productivity, transfer skills and technology, enhance exports, and contribute to the long-term economic development of the world's developing countries. But infrastructure projects can be hindered by high commercial risk and a weak regulatory and institutional environment in the country concerned.

International organisations play a major role in providing a favourable framework for FDI. Several organisations work on a regional level to promote regional energy cooperation:

- The Asia-Pacific Economic Cooperation (APEC) forum deals with economic and trade issues. It aims to maximise the energy sector's contribution to the region's economic and social well-being.
- The Asian Development Bank (ADB) aims to promote member countries to develop into thriving modern economies that are well integrated with each other and the world. It is concerned with energy because access to (clean) electricity is crucial for development.
- The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), the regional development arm of the United Nations for the Asia–Pacific region, plan regional cooperation for enhanced energy security and for the sustainable use of energy in Asia and the Pacific.
- The International Renewable Energy Agency (IRENA) seeks to make an impact in the world of renewable energy by maintaining a clear and independent position and providing a range of reliable and well-understood services that complement those already offered by the renewable energy community.
- The Energy Charter (EC) provides a multilateral framework for energy cooperation. The EC plays an important role as part of an international effort to build a legal foundation

for energy security, based on the principles of open, competitive markets and sustainable development.

The members of the Energy Charter concluded the Energy Charter Treaty (ECT), which is a legal framework for long-term energy cooperation based on mutual benefits for energy-producing, energy-consuming as well as transit countries. The EC plans to include more key energy players within the consolidation, expansion and outreach (CONEXO) program (policy paper). The EC provides a policy platform between its signatories and observer states to discuss political and legal aspects related to implementation of Gobitec and ASG for renewable energies in NEA. The ECT develops legal instruments to protect and promote investment in energy technologies; in addition, it minimises the risks of investment for energy investors and proclaims state sovereignty over countries' energy resources. In accordance with the principles of freedom of transit and in securing established energy flows, the ECT requires the participating states to take the necessary measures to facilitate the passage of energy.

Technology transfer is another important factor for the success of the Gobitec project. Within Gobitec there are three main channels of technology transfer: Sale of equipment and patented know-how, turn-key projects as well as transfer(s) at the time of large oil and gas exploration projects. The ECT countries agree to promote access to and transfer of technology on a commercial and non-discriminatory basis to assist effective trade in equipment with full respect for the protection of intellectual property rights. In addition, the ECT framework serves as a support to provide legal grounds for the contracting parties for future technology transfer.

From the analysis of the existing regulatory framework in the ASG region, the following conclusions can be drawn:

- Because the ASG project is capital intensive and developed on the principles of the EC, an improved investment climate for the ASG region is necessary.
- Because of the regional character of the project with high voltage electricity lines, regional stability in the region will be necessary.
- Because China and Mongolia provide weak protection of intellectual property rights, technology transfer must be accompanied by improved property rights.
- In developing renewable energy sources and cross-border energy infrastructure, the cooperation of international organisations and financial institutions, including APEC, ESCAP, IRENA, EC and ADB is required to support the countries in NEA.
- It may be necessary to provide a platform for further consultations on cooperation in NEA in which these may be supported by the EC and other stakeholders. Mongolia should also participate in the promotion of the EC process in the region.

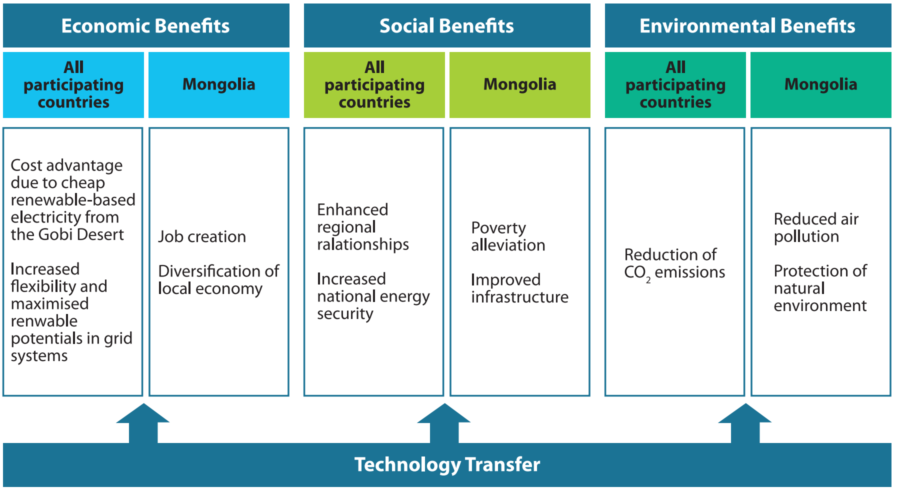
Benefits of regional integration

Key message:

The Gobitec and ASG project will deliver a number of economic, social and environmental benefits to Mongolia and to the other participating countries. These benefits include, among others, job creation, poverty alleviation and a reduction of carbon dioxide (CO_2) emissions.

The Gobitec project will have a number of benefits for the Southeast Asian region. Benefits of system integration for Mongolia and the other participating countries are of an economic, social and environmental nature. A summary of the benefits of regional integration is illustrated in Figure 1-5.

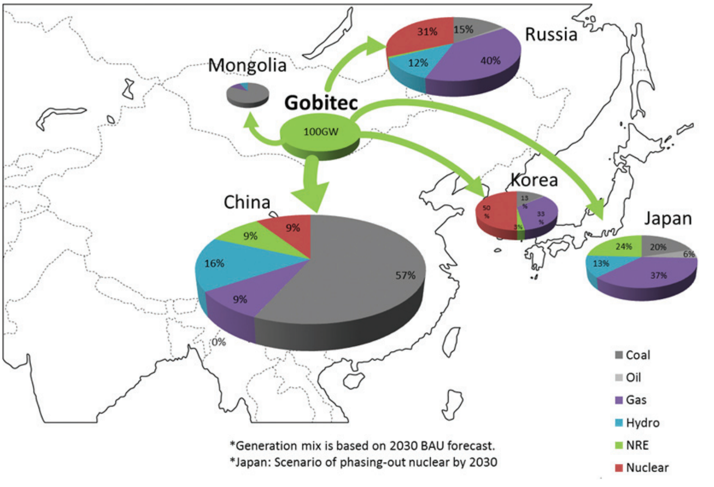
Figure 1-5: Summary of the benefits of regional grid integration for Mongolia and other countries participating in the Gobitec project



Job creation due to the Gobitec project was calculated in this study using the employment factor method. A capacity of 100 GW renewable energies, consisting of equal shares of PV and wind technology, would create nearly 880,000 direct jobs. These positions would be composed of about 400,000 jobs in the PV industry and 480,000 jobs in the wind sector. Photovoltaic-related jobs will mainly be in the construction sector, while a large share of the wind-related jobs will be in the manufacturing of the turbines. In total, the two renewable technologies will create an income of more than 9 billion USD in Mongolia over a 16-year period. Along with the job creation effect, the local economy of Mongolia will profit from diversification. Currently, the economy is heavily dependent on the mining industries; job creation in the renewable energy technologies will reduce this dependency.

But it is not only Mongolia that will profit from these employment effects: Outside the country the Gobitec project is expected to generate about 510,000 directly and indirectly related new jobs over a 16-year period. This number comprises 370,000 jobs in the PV industry and 190,000 jobs in the wind energy industry. On a regional level, 140,000 jobs will be created by the construction and maintenance of the transmission lines during the construction time. Gobitec and ASG may also yield a diversification of the electricity mix for the participating countries. Figure 1-6 shows the expected diversification in the electricity sector.

Figure 1-6: Generation Mix of 2030 and importing RE from Gobitec



A large interconnection system as well as a high share of renewable energies will decrease the cost of electricity for NEA countries because renewable energy potential is large in the Gobi Desert. In addition, the interconnection makes a balance of supply and demand in all participating countries easier for three reasons: (1) Greater spatial diversification can smooth the electricity generation due to varying meteorological conditions, (2) Countries can share dispatchable power plants and storage facilities, allowing for more economic operation of the country's power plants, and (3) ASG countries have different times of peak electricity demand because of different time zones as well as seasonal differences in the load curves. For example, in South Korea demand peaks during winter times, whereas in Japan the peak occurs in the summer. Therefore, connecting several countries with one grid simplifies the supply and demand balance.

In comparison to fossil-fuelled electricity generation, renewable energy technologies cause very low emissions. By providing renewable energy electricity to satisfy the growing energy demand in the region, emissions of carbon dioxide, sulfur oxide, nitrogen oxide, dust, and other pollutants can be avoided or reduced. Consequently, indoor air pollution will be reduced, which contributes to the protection of the natural environment of Mongolia. The Gobitec project may result in a CO_2 emission reduction of about 187 Gt per year. On a larger scale, the reduction of CO_2 emissions may be a benefit for the whole region owing to the mitigation of climate change.

Through the Gobitec project, access to electricity in rural areas of Mongolia may be increased as a result of the new and upgraded electricity infrastructure. Rural electrification may also create poverty alleviation because hospitals and healthcare services profit from increased availability of electricity and can therefore provide better services. Also, small businesses will proliferate with the provision of electricity to communities. Therefore, it is expected that the Gobitec project will significantly contribute to poverty alleviation in Mongolia. On an international basis, the Gobitec project will enhance economic activities because the project implies the improvement of regional relationships and an increase in national energy security among all participating countries.

Important remarks on the feasibility, overall renewable energy potential and resources

Key message:

The overall potential of solar and wind energy in the Gobi Desert is about 2,600 TW.

The renewable energy potential in the Gobi Desert is vast. The overall potential for installed renewable energy capacity, only for the Mongolian part of the Gobi Desert, is estimated by the National Renewable Energy Laboratory (NREL), US Department of Energy to be about 2,600 TWh. This divides into a wind onshore potential of 1,100 TWh and a solar power potential of 1,500 TWh.

However, these pure numbers only give a rough overview of the possibilities of the Gobitec vision. Land availability/use, detailed potential, grid conditions, distances to demand centres and – most important – the political implementation and the financial requirements need to be taken into account if the technical potential is to be found. The planned installed capacity of roughly 100 GW is a very large project size. The overall cost for the project is estimated to be around 293 billion US dollars, with yearly maintenance and system cost of 7.3 billion dollars.

Therefore, at this early point, it is important to mention that this study does not aim at a detailed built-up and action plan. It also does not present a detailed potential or a modelled scenario analysis owing to the limited time frame of the project. However, the study can provide a sense of magnitude of the project and make preliminary estimations on potential, prices and benefits.

Perspectives on integrating renewable energy sources

Key message:

Renewable energy sources such as PV and wind will be grid-connected and combined with dispatchable technologies to balance supply and demand.

Some renewable energy technologies such as PV and wind are usually dependent on the availability of energy resources, meaning that electricity supply from renewable energy is mainly volatile. In order to match the electricity demand, the volatile output of the renewable energies needs to be balanced with a dispatchable energy source. An energy source is dispatchable if its output can be regulated to fit a certain demand curve. This is achievable by using, for example, concentrated solar thermal (CSP) power plants with storage, and by encompassing controllable hydropower plants or fossil-fuelled power plants into the energy system.

In order to exploit the benefits of non-dispatchable renewable energy technologies for the Gobitec project, a balancing source of electricity needs to be included. This combines the advantages of wind and solar energy with the stability of a system which can respond to the demand. Electricity production by renewable energy sources is complemented with an existing fossil-fuelled electricity supply. In addition, a large grid will contribute to the stable operation of the energy system.

[1] *Considering photovoltaic and solar thermal technologies.*

Figure 1-7: Solar project, Mongolia

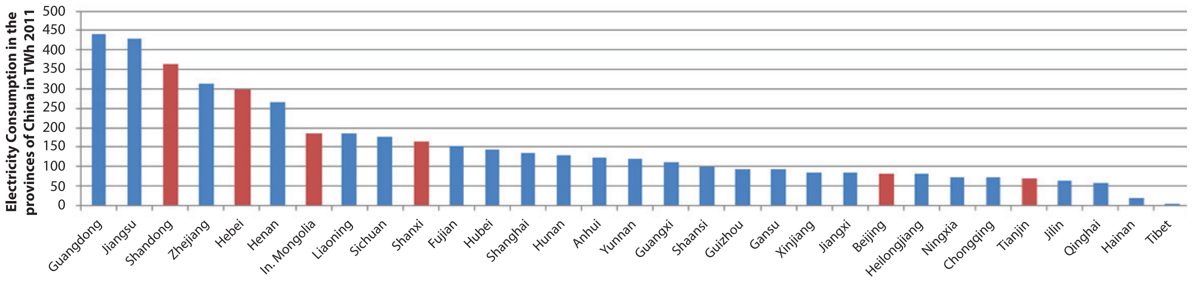
Sustainability and security of supply and outlook on further analysis

Key message:

The Gobitec and ASG projects have the potential to meet the challenges of the energy supply in NEA. Therefore, the spatial distribution of the renewable energy potential as well as the policy environment need to be assessed.

The electricity demand of NEA will grow rapidly in the coming decades. The highest increase per capita in the last years (2000–2010) had been registered in the Republic of Korea (5,900 kWh to 9,700 kWh) and China (993 kWh to 2,900 kWh). The demand per capita was relatively constant in Mongolia and Japan. Looking at the absolute values, a tremendous increase in demand in China from 1,347 to 4,193 TWh can be observed. In 2011, in the context of Gobitec it is important to note that 1,165 TWh of this demand occurred in the provinces which are within a possible Gobitec corridor. Some provinces are directly neighbouring the Gobi Desert and cities like Beijing are within a distance of 600 km.

Figure 1-8: Electricity demand of China´s provinces in 2011 (Source: APGE-China)



This demand offers huge opportunities for China to include further renewable energy capacities in its electricity system. But from the perspective of Korea, Japan and Mongolia, there are opportunities to benefit from Gobitec because of the reduction of carbon emissions and decreasing dependency on fossil fuels.

Compared to other NEA states, South Korea and Japan are more vulnerable in terms of energy security; as they have almost no natural resources both countries are highly energy dependent. Korea imports 96% of primary energy from abroad, 82% of its oil imports are purchased from the Middle East (IEA, 2012a). Currently Japan's energy self-sufficiency, excluding nuclear power, is merely 4.9% (IEA, 2012c). To narrow the gap between rising energy demand and deficient energy supply, it is necessary to tap the potential of regional renewable energy.

In deciding where and how the investment should be started, the overall risk is similar to other mega projects. Generally, the first step is to assess the renewable energy potential in the area and investigate how – based on this potential – deployment, based on different criteria, could be realised. This techno-economic analysis has been done recently for the Middle East and North Africa regions in the context of DESERTEC by the DESERTEC industrial initiative (Dii). The first project showed in a target picture what a techno-economic optimal target picture looked like. In a second step, a more detailed regional analysis had been performed to see the different pathways of deployment.

The second step is to analyse the overall policy framework and identify the existing weaknesses. The overall objective should be the development of a cooperative framework which would optimally support the target picture developed in the techno-economic analysis. It should also consider technology transfer and financial conditions.

Enhancing regional cooperation

Key message:

Regional cooperation can play a key role in establishing the Gobitec and ASG project. An international platform for facilitating electricity exchange and an improved investment climate may be inalienable. Also, this cooperation needs to ensure the equal distribution of project benefits to all participating countries.

Further progress in Gobitec and the ASG strongly depends on regional cooperation in NEA. A supranational strategy is needed in order to develop the project to such an extent that legal certainty is assured for the participating countries, investors and other stakeholders. The focus should also be on a joint energy cooperation strategy in which the participants can align their targets and harmonise them with national renewable energy strategies. The dialogue can be established and continued with institutions such as ESCAP and through the inter-governmental collaborative mechanism on cooperation in Northeast Asia (ECNEA).

Bringing the megaproject, Gobitec/ASG, on track requires a lot of effort and negotiations in eliminating physical, trade and regulatory barriers to ensure a beneficial electricity market in NEA. As the countries have different target/policy structures and different industrial structures, the processes involved may present obstacles. It may be appropriate to create joint development districts, allowing an assessment of the legal framework and potential before implementing it into the national systems.

Furthermore, an improved investment climate requires a harmonised set of trade and transit rules. This set of rules has to be developed to reduce investment risks and create a joint platform of electricity exchange. The exact form that this exchange should take has to be evaluated by further research and discussions, mainly within an international platform. The focus should also be based on an efficient system which can benefit all participants. The transit rules should be transparent and clear to ensure that countries at the end of the ASG spectrum have the supply security that is needed. Regarding the disparity between generation and consumption, the interdependent relationship between the countries should be made clear, and the demand for transparent and non-discriminating rules should be emphasised.

The most important objective is that cooperation should be structured in such a way that benefits are concentrated not only for a few countries but are distributed among all participants. This is difficult to achieve, but it is fundamental to the understanding of the Gobitec/ASG project.

Conclusions

Key message:

At the moment, the Gobitec and ASG are still a vision. The first steps for implementation will entail further research as well as the set-up of an international platform for discussion. Regarding the idea of Gobitec, small-scale projects with regional, national and bilateral perspectives should be developed to reduce complexity.

What are the conclusions of this first study of the potential, technological and political feasibility of the project? It is difficult to provide a definite answer to this on the basis of the present state of analysis. The topics covered in this initial study include the technology and cost implications, the socio-economic benefits that could arise because of the Gobitec/ASG vision and the recommendations on policy implementation and regional cooperation.

Given the available technology and the parameters that have been set, the implications indicate that the technological feasibility of Gobitec/ASG is technically possible. However, the whole system is complex and the HVDC transmission technology is not field-tested on a large scale. Therefore, further technological research is needed to identify the optimal technology mix in terms of transmission and generation.

In addition to the technological complexity, the cost of nearly 300 billion US$ appears very high. This raises the question of which institution or investor might be interested in investing in Gobitec. This is an important consideration because, given the high financial and legal risk involved, only venture capital investors may be attracted to it. One solution might be to reduce the investment risk by a stable and transparent legal framework which had been developed on an international platform. Only then could the risk, and therefore the cost of capital, be reduced to a level that could turn the vision into a reality. Creating such a non-discriminatory framework is crucial for the realisation of Gobitec/ASG.

Considering the risks mentioned above, it is also a recommended strategy to start with developing smaller projects and aligning them along the Gobitec/ASG vision. Such projects could be started nationally and later be evolved into bilateral projects.

If Gobitec/ASG should become a reality, it will offer several opportunities: Firstly, it could deliver energy from renewable sources to the participating countries, helping them to reduce emissions and cause an investment shift into renewable technologies. Secondly, the deployment and operation of the system could realise benefits for the participating countries in NEA, enabling countries like Mongolia to introduce a new industry, or open up new opportunities for existing businesses. Thirdly, it may help Japan, South Korea and China to satisfy their electricity demands for a cleaner source of energy than that provided by the conventional or nuclear power plants. Ultimately, it may also help to intensify cooperation between the states; thereby proving that they can keep such a complex investment on track.

Gobitec is still a vision. At present the risks of failure are huge and can merely be estimated. Therefore, further research and an international platform are needed to develop a stable and fair legal framework.

Figure 1-9: Solar project, Mongolia

THE TECHNOLOGIES AND COST IMPLICATIONS

This chapter describes the entire technical concept and cost implications in which technology can be an optimal solution for the Gobitec and ASG project. The methodology used in interconnecting this complex total system with each country's power system will be discussed in detail. Considering both technical and economic factors, the supply unit cost will be estimated for the total supply unit cost (TSUC) [$/kWh] for the Gobitec and ASG project and compared with the TSUC value for the weighted average electricity charges (WAEC).

Above all, the technology, among high voltage alternating current (HVAC), CSC-HVDC and VSC-HVDC, that is more appropriate in technical points and more profitable in economic terms for this grand cross-border interconnection case has to be determined. In addition, based on the determined technology, the overall concept design and basic system configuration will be displayed for the total generation system combined with solar and wind farms, cross-border ASG interconnection system and local interconnection to each country's power system. Finally, for the combined Gobitec and ASG system, this study will calculate the TSUC ($/kWh) and compare this value with each country's electricity price and the WAEC ($/kWh).

Special case study on potential of Gobitec

This section specifies the overall design system and configurations that are based on the estimated total developable generation capacity (GW) of the Gobi Desert, from the technical and economic viewpoints. Starting with the total developable capacity, the collecting and transmission capacity can be discussed in relation to where technology should be applied. This is the concept design of the overall system configuration for the Gobitec and ASG project. Gobitec is composed of many local solar and wind farms. The ASG concept means the cross-border power trade transmission trunk line that has the capacity over the total generation farms. This cross-border line will transmit the bulk power (more than a hundred of GW) from Gobitec renewable energy resources (solar and wind farms) to each country: Mongolia, Russia, China, Korea and finally Japan.

The cross-border power trade will be produced through supplying a corridor system connecting counterpart countries which want to buy or sell bulk electricity. In addition to the ASG cross-border transmission line, each country should construct the local interconnection line from the ASG trunk line to its own power system connection point of common coupling (PCC).

The Gobi Desert is geographically located in the boundaries of Mongolia and China. This project of developing renewable energy resources in the Mongolian Gobi Desert is mainly focused on the solar and wind energy of that desert territory. Geographically, Beijing, Seoul, and Tokyo are in the south-east direction of the Gobi Desert, whereas Ulaanbaatar and Irkutsk are in the north-west region.

Considering geographical conditions, if the Gobitec and ASG project were constructed for cross-border transmission, the renewable electricity energy produced in neighbouring NEA countries, and the energy transmission routes will be sited in two directions: one, upwards to the Ulaanbaatar and Irkutsk direction; the other, downwards to Beijing, Seoul and Tokyo. There are interconnected transmission lines to exchange power between these routes. Irkutsk, capital city of East Siberia, is near the Baikal Lake and this region has abundant water resources. Therefore, the surplus hydro power of East Siberia could be added to the Gobitec renewable power supply when exporting the electricity to the other NEA countries through ASG. This means that only Russia and Mongolia are the exporting countries; and the rest, China, Korea and Japan import electricity.

Figure 2-1 shows the map of the Gobi Desert and its neighbouring countries.[2] Table 2–1 describes the direct distance, derived from this Google Earth map, from the centre of the Mongolian Gobi Desert to the capital or major cities of each country. Considering the natural geographical conditions, the practical length of the transmission line will be 1.15~1.25 times of the direct length between major cities, depending on each country's geographical conditions. For instance, although the direct distance between Beijing to Qingdao is just 550 km, maybe the transmission will be a distance of about 650 km.

Figure 2-1: Map of Gobi Desert and neighbouring countries

Table 2-1: Direct distance from Gobi Desert to major city [km]

City	Distance	City	Distance	City	Distance	City	Distance
GOBI–Ulaanbaatar	430	Beijing–Shanghai	1065	Shenyang–Dandong	215	Seoul–Busan	325
GOBI–Beijing	745	Beijing–Qingdao	550	Dandong–Pyongyang	160	Busan–Fukuoka	215
GOBI–Shenyang	1130	Qingdao–Seoul	610	Pyongyang–Seoul	190	Fukuoka–Tokyo	880
Ulaanbaatar–Irkutsk	520						

[2] Tackling climate change, increasing energy security, engaging North Korea and moving forward Northeast Asian integration – "Green Growth" in Korea and the Gobitec project" Dr. Bernhard Seliger – Prof. Gi-Eun Kim.

Since 1990, a number of research reports have been available for renewable energy resources in Mongolia and in the Gobi Desert. All of the reports published on Mongolian renewable energy have some different specific data on solar and wind energy density, total capacity and annual generation potential. Regarding all data about Mongolian energy statistics, the common fact is that Mongolia and the Gobi Desert have tremendous amounts of renewable resources, especially in relation to solar and wind energy. Nobody doubts this common fact. Formal statistics on Mongolia's renewable energy resources are shown in Table 2–2. In this table, some of the detailed physical, economic and technical potentials were not known precisely until now.

Table 2-2: Mongolia Energy Status

Energy Source	Physical Potentials (MW)	Technical Potentials (MW)
Solar PV	2.2×10^{12} (MWh/year)[3]	N.A.*
Solar WH	6200[4]	1000
Hydro	N.A.	N.A.
Biogas	N.A.	N.A.
Wind	N.A.	4,300,000[5]

** = not applicable.*

According to the NREL of the US department of energy (DOE), the wind energy potential of Mongolia is about minimum 1.1 TW and solar potential is about 1.5 TW. The total potential of Mongolian renewable energy, including wind, solar, geothermal and hydro resources can be as great as 2.6 TW capacity. The average wind energy density is 7 MW/km^2 and solar energy density is 66 MW/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. This is the equivalent density of 400~600 MW/km^2. Also, the Gobi Desert region of Mongolia alone has an estimated average solar electricity generation potential of 5.4 kWh/m^2/day. If all of the Gobi Desert with 1,300,000 km^2 is covered with PV cells, the total annual power production would record up to 13,261 TWh; and this value will be about a 66% portion of total worldwide electricity generation.

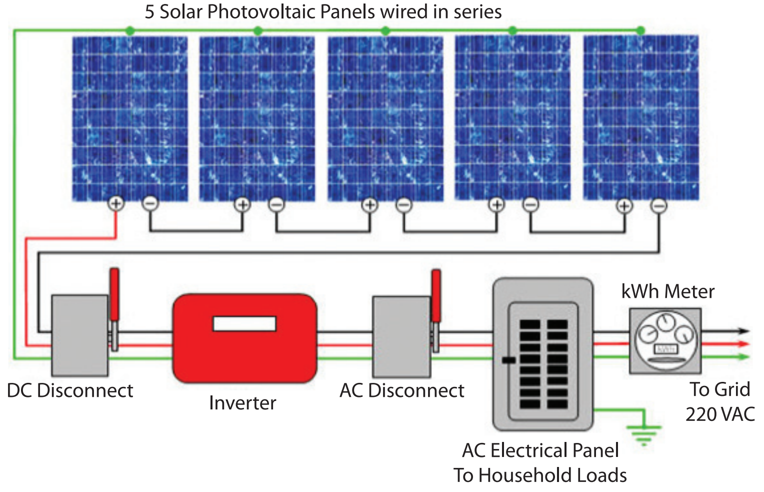
Solar and wind power generation is the main and the largest scale energy source of renewable resources, especially for the Gobi Desert conditions. From a technical point of view, solar power generation is divided into two types: solar PV panels and water heating generation by using natural solar energy. Whether PV panels or water heating, use of solar energy to produce electricity is the commonest technology. Also, the wind power is generated by onshore desert wind turbines in Gobi, not by offshore devices. Both solar and wind power generation sites occupy reasonably wide areas and solar energy sources are required for about twice wider areas than wind energy.

3 *ADB, Promotion of renewable energy, energy efficiency and greenhouse gas abatement, 2004.*

4 *NREL, Atlas of Wind Energy Resource in Mongolia, 2000.*

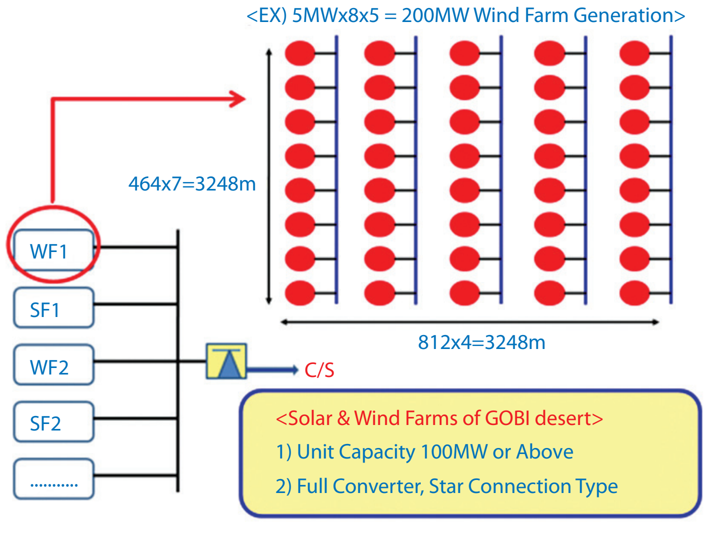
5 *8 NREL, Atlas of Wind Energy Resource in Mongolia, 2000.*

Figure 2-2: Sample system of photovoltaic generation[6]



(a) Typical arrangement model for wind power turbine

Figure 2-3: Sample configuration of complex solar and wind farms[7]



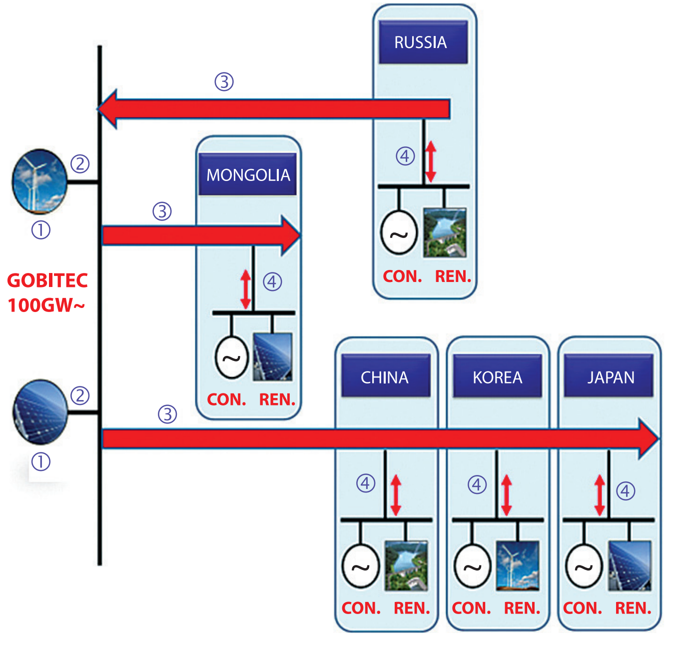
(b) Parallel displacement sample of solar and wind farms

6 http://saesang.blog.me/80189713048
7 "Basic concept design For GW-Level Offshore wind farms with HVDC interconnection system" 2012 KERI.

Solar and wind-generated energy will transmit to electricity importing countries through cross-border transmission lines. Cross-border transmission lines can be classified into overhead transmission lines on land and submarine cables on sea.

Therefore, in consideration of all the above mentioned conceptual structures, the total system configuration will be displayed as shown in Figure 2-4. From this figure it is seen that Russia is an electricity exporting country using abundant hydro power plants. On the other hand, Gobitec-produced energy will be transmitted to the importing countries China, Korea and Japan in a downwards direction and to the exporting country Russia in an upwards direction.

Figure 2-4: Conceptual configuration of Gobitec plus ASG



The overall Gobitec plus ASG system is divided into four parts: ① solar/wind farms for generation, ② a collecting system, ③ a cross-border transmission system, and ④ a connecting system. The collecting system integrates each solar and wind farm into a sender system and these combined renewable generation outputs will supply energy to imported countries through ASG; the bulk cross-border transmission system, and the connecting system interconnect the ASG to each country's power system.

Firstly, the generating sources for the Gobitec project are composed of multi wind and solar farms, encompassing many small regional and subregional renewable power-plant sources. For instance, a regional solar farm combined with a wind farm has many small sources separated into equal spaces, as illustrated in Figure 2-5. These small regional renewable sources spread into relatively wide desert land and some integrate into generation centres. Using the HVDC cross-border corridor, these integrated renewable generated power units could be transmitted to load centres connecting each country.

Therefore, some technical and economic impacts for Gobitec generation, such as cross-border transmission and the connection system can be studied. The occupied areas and technical and economic characteristics of renewable sources of energy are quite variable, depending on the nature of the corresponding sources. For instance, 1 GW of offshore wind farms occupy an area of 65 km^2 which is just one example, but the solar farm with the same capacity is quite wider than the wind farm.

From a technical viewpoint, the Gobitec project and the wind and solar power systems have complementary characteristics although the vulnerability is high all day long. The production of solar energy is limited in the daytime, but wind energy could produce energy all day long with high volatility.

In this total system, the most important things to be determined technically are the overall configurations and the general idea of the structures. Although this study is merely a concept design, it will also discuss some basic technical system specifications for further economic and legal research in this project. The contents mentioned below are the core items which should be discussed in order to determine the overall design concept.

This collecting system with the hundreds of GW capacity will have a very complex hierarchical structure with unit solar/wind farm, sub-local solar/wind farm, local solar/wind farm and total collecting station (TCS), considering total bulk capacity and the widespread area for generation.

Figure 2-5: Sample configuration of unit solar or wind farm

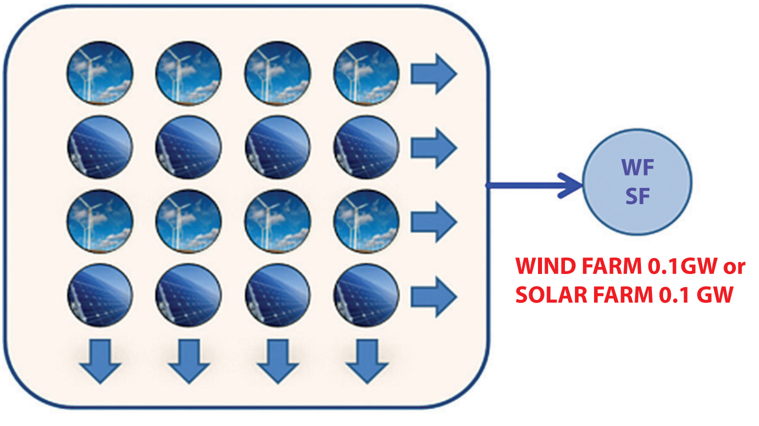
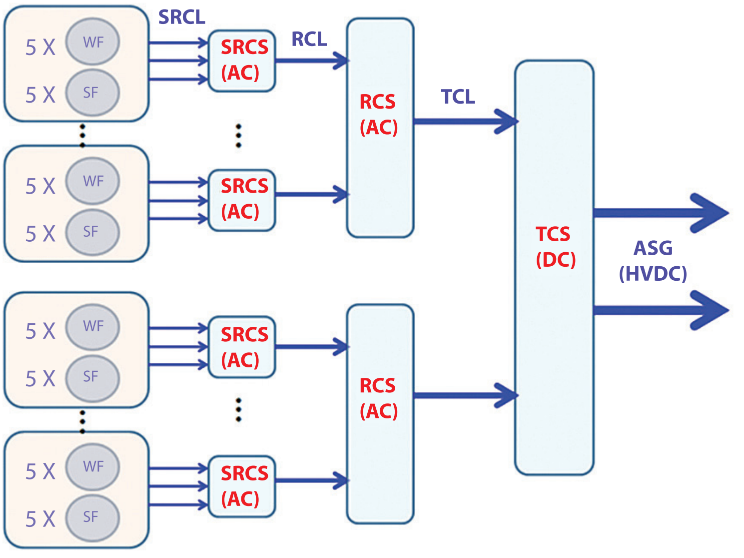
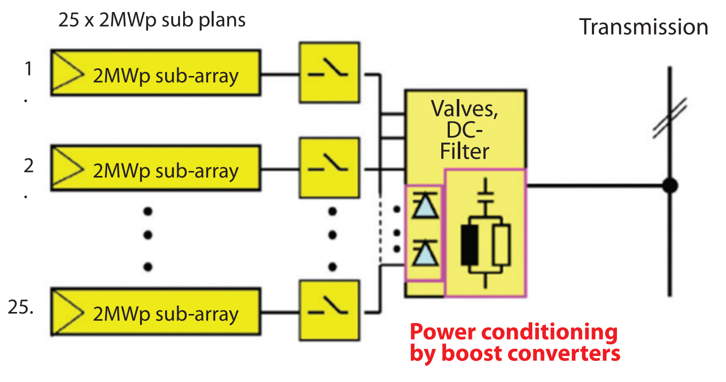


Figure 2-6: Complex hierarchical structure of Gobitec NRE sources[8]



All these many local solar and wind farms will be gathered into one or more collecting point, the so-called TCS in order to transmit the generated electricity through ASG into each country's power system using the subregional hierarchical structure. The subregional collecting line (SRCL) is the integrated transmission line and the station is SRCS; the regional collecting line (RCL) connects to a regional collecting station (RCS) from the SRCS. Also, TIL represents the total collecting line from the RCS to the TCS, connecting each RCS to a TCS.

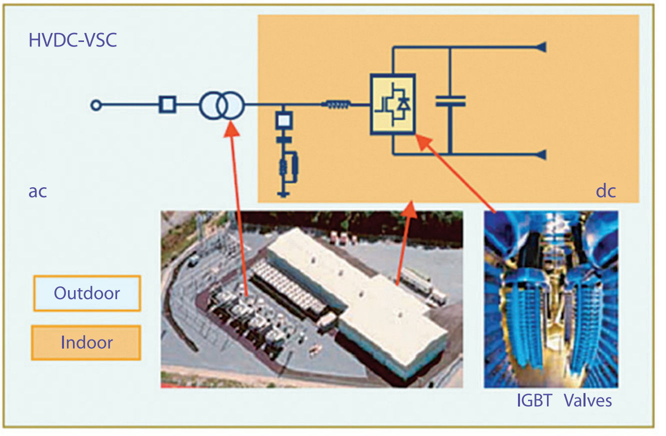
Figure 2-7: Example of advanced solar or wind unit HVDC grid system[9]



[8] TCS(Total Collecting Station), RCS(Regional Collecting Station), SRCS(Sub Regional Collecting Station), SRIL(Sub Regional Interconnection Line). RIL(Regional Interconnection Line), TIL(Total Interconnection Line).

[9] http://www.ssb-foundation.com/Energy%20from%20the%20Desert%20Summary.pdf, energy from the desert

Figure 2-8: Sample configuration of VSC-HVDC converter station



Where solar and wind generators are concerned, there is a big difference in relation to generation. Based on inherent technical characteristics, solar systems generate DC power, whereas wind systems produce alternating current (AC) power. These local solar farms are collecting sets of many PV modules and a module is also an aggregation of many PV cells. This solar farm produces electricity as a DC type. In contrast to a solar farm, a local wind farm is also composed of so many small-sized wind generators with a capacity of a few MW.

For the concept design of this collecting system, it is necessary to consider the following parameters and topics:

1. Hierarchical structures and basic spec.

- Capacity (GW) of total solar and wind generation system (ex) over 100 GW
- Number of total solar/wind farms and their unit standard capacity
- Number of SRCS and unit capacity
- Number of RCS and unit capacity
- Number of TCS and unit capacity ex) 1 (100 GW) or 2 (50 GW)

2. Technical spec.

- Applied technology spec. to collecting generated power to Sub Regional Converter Station (SRCS), Sub Regional Collecting Line (SRCL), Total Collecting Line (TCS), ex) AC or DC [VSC or CSC Type] spec
- Technical type of ASG corridor system (transmission station and line) and voltage (kV) ex) High Voltage Alternating Current (HVAC) or High Voltage Direct Current (HVDC) have two types, one is Voltage Source Converter (VSC-HVDC) or Current Source Converter (CSC-HVDC) multi terminal system
- Voltage and length of ASG transmission line

The system of configuration of bulk renewable energy sources with multi solar and wind farms will get very complex because of the integrated structure as mentioned above. Although a detailed technical study is out of range for this study, the overall detailed configurations of these combined renewable sources should be designed in line with many regional wind and solar farms in the future.

Forecast of conventional power technologies in Northeast Asia

Each country in NEA has its own inherent conventional power industry model in terms of primary energy supply/demand, power generation mix (hydro, nuclear, thermal [gas, oil, coal]) and power system characteristics and experiences of HVDC systems. But, renewable resources such as solar, wind and geothermal energy will be a popular and major consideration for the power industry when considering its long-term future.

This section briefly describes the power system and power industry status of NEA countries subject to the Gobitec and ASG project. The prospect of power demand and supply plan for all countries, installed capacity (MW) and generation output (TWh), is shown in Table 2-3 as well as in Figure 2-9 to Figure 2-11.

In 2010, China had the largest installed generation capacity of over 935 GW, dominated by coal (658 GW) and hydroelectric power (216 GW). China's expected high economic growth rate means its electricity demand will surpass all other countries by the end of the outlook period. It is expected to reach 8,510 TWh in 2030, as shown in Table 2-3. With the exception of China, the installed capacity and generation amounts of all other country's power industry, such as that of Korea, Japan and Russia will saturate and have a relatively low growth rate. Mongolia has three small power systems which, although widespread, are small capacity units of about 1 GW. These three systems are separated from each other and the only central power system is an interconnected system, whereas East and West power systems are now operated separately. Mongolia is a rich country in natural resources, especially in relation to solar and wind energy of the Gobi Desert. At present, most of Mongolia's generation mix is composed of coal generators, apart from some diesel generators in separately operated generators in rural areas. Renewable sources of solar and wind may possibly be a major generation mix if Gobitec and other renewable resources are developed in Mongolia.

The Fukushima Nuclear Accident of March 2011, has somewhat changed the nuclear outlook in the APEC region. Higher safety standards, increasing costs and construction times, as well as eroding public acceptance of nuclear energy power plants mean that the APEC economies will become more cautious in expanding their nuclear generation capacity. The nuclear generating capacity projection has been revised to reflect this situation, especially in Japan. The nuclear capacity of some countries is missing in the tables shown below, but the generation data is displayed. It is not known why the nuclear installed capacity has been omitted from the APEC statistics.

If the Gobitec plus ASG project can be realised as a global supergrid network, then the HVDC system may be adopted as an interconnection technology. Among NEA countries, Russia, China and Japan have the domestic HVDC system design, construction and operation technology with the maximum level of 800 kV and a few GW. Korea has a poor experience of the HVDC technology compared with China, Japan and Russia. Mongolia, however, has no HVDC system application and related technology. However, many worldwide countries have no experiences of the HVDC system application, having capacities greater than 10 GW until now. This is why the research & development (R&D) project on HVDC supergrid technology should be prepared in order to realise the objectives of the Gobitec and ASG project.

Table 2-3: Installed capacity (MW) and Generation (TWh), (Based on BAU (Business-As-Usual) Scenario

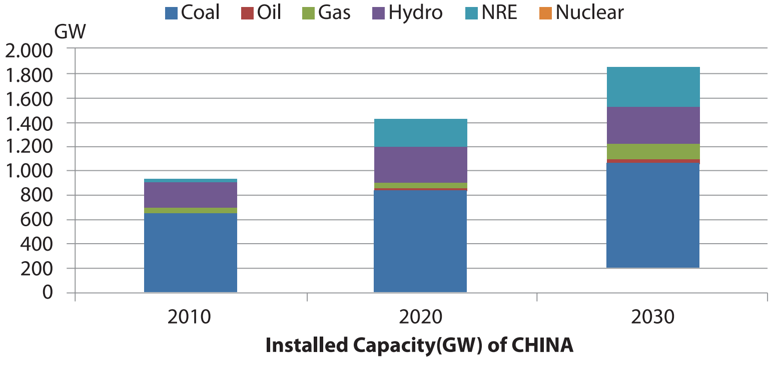
Country	Source	Installed Capacity(MW)			Generation(TWh)		
		2010	2020	2030	2010	2020	2030
Korea[10]	Coal	24,205	44,394	45,394	1981)	112.8	80.4
	Oil	4,479	3,849	1,249	11	8.0	3.0
	Gas	26,311	41,028	39,228	126	197.9	202
	Hydro	3,900	4,700	4,700	2.8	1.9	1.6
	NRE	3,373	20,066	32,014	8.2	2.6	15
	Nuclear	17,716	30,116	35,916	149	237.5	303.7
	Total	79,984	144,153	158,501	495	560.7	605.7
China	Coal	658,129	841,314	1,078,493	3242.6	4,090.4	4,829.2
	Oil	8,352	8,492	6,777	17.0	5.3	0.4
	Gas	26,423	63,110	143,302	69.6	221.4	758.7
	Hydro	216,057	290,000	309,490	747.1	1,203.1	1,370.4
	NRE	26,628	220,869	331,116	51.5	502.0	762.3
	Nuclear				80.8	458.5	789.8
	Total	935,589	1,423,785	1,869,178	4,208.6	6,480.7	8,510.8
Russia	Coal	52,172	55,772	60,372	183.8	227.6	223.9
	Oil	5,200	5,200	5,200	16.5	15.6	14.3
	Gas	100,660	109,660	121,160	487.9	546.8	593.2
	Hydro	55,000	56,800	59,100	179.7	180.7	176.7
	NRE	820	1,720	2,870	3.1	6.2	10.7
	Nuclear				163.8	301.8	472.7
	Total	213,852	229,152	248,702	1,034.8	1,278.7	1,491.5
Japan	Coal	40,264	41,864	44,264	281.7	287.4	296.0
	Oil	54,047	44,967	35,887	77.9	45.8	20.1
	Gas	83,152	86,555	87,955	302.5	328.7	349.7
	Hydro	47,966	51,026	52,216	87.0	108.1	111.7
	NRE	9,789	39,506	54,564	33.4	87.2	119.5
	Nuclear	48,960	35,554	21,226	289.0	218.6	130.5
	Total	284,178	299,472	296,112	1,071.5	1,075.8	1,027.5

[10] *6th Power Supply and Demand Plan, Korea.*

Table 2-3: Installed capacity (MW) and Generation (TWh), (Based on BAU (Business-As-Usual) Scenario

Country	Source	Installed Capacity(MW)			Generation(TWh)		
		2010	2020	2030	2010	2020	2030
Japan Zero Nuclear Scenario	Coal	40,264	37,305	28,084	281.7	256.1	192.8
	Oil	54,047	40,641	51,545	77.9	86.1	52.5
	Gas	83,152	90,689	92,611	302.5	344.4	351.7
	Hydro	47,966	54,000	51,545	87.0	114.4	128.0
	NRE	9,789	42,134	104,202	33.4	93.0	230.0
	Nuclear	48,960	23,486	0	289.0	144.4	0
	Total	284,178	288,255	336,862	1,071.5	1,038.4	955.0
MONGOLIA	Coal	689	1610	2820	3417	9282	14279
	Oil	10	-	-	-	-	-
	Gas	-	-	-	-	-	-
	Hydro	25	200	500	0.088	0.7	1.75
	NRE	4	205	450	0.01	0.62	1.3
	Nuclear	0	0	0	-	-	-
	Total	728	2015	3770	3515	10602	17329

Figure 2-9: Installed capacity (MW) and generation amount (TWh) of China



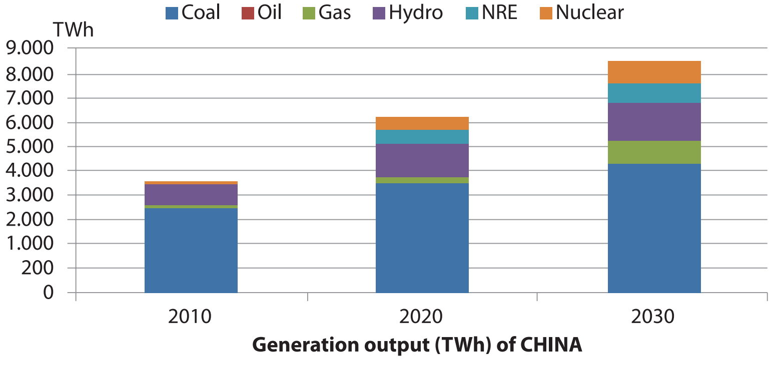
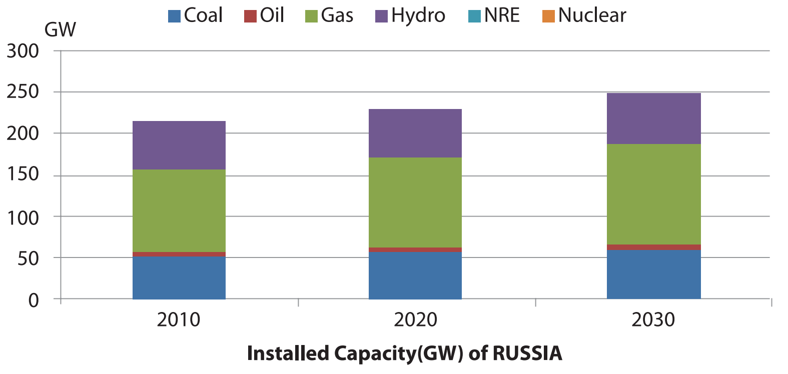


Figure 2-10: Installed capacity (MW) and generation amount (TWh) of Russia



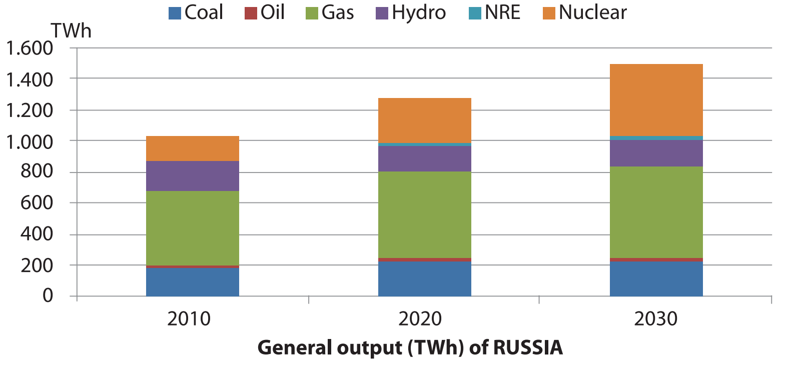
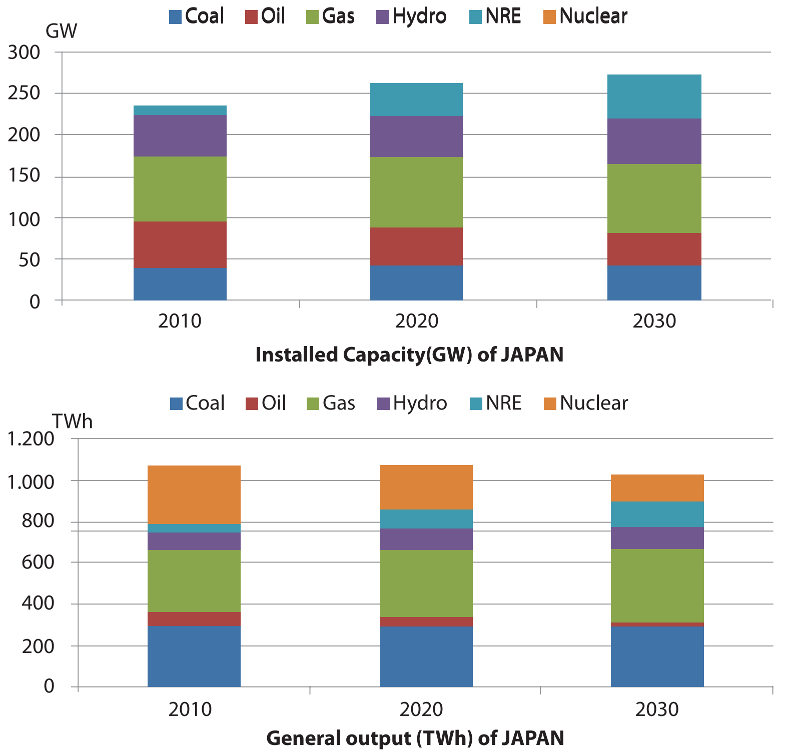


Figure 2-11: Installed capacity (MW) and generation amount (TWh) of Japan



Basic characteristics of renewable energy sources and their technical impacts on power system operations considering conventional supporting generating plants

Renewable energy sources do not use fossil fuels, but have the advantages to protect the global environment and the sustainable fuel development with infinite persistence. This effect could reduce total carbon emissions. However, this renewable energy system has output volatility, but the initial investment is very large. Also, the power system operation has both low stability and supply reliability because of frequent output variations.

All the renewable energy sources both solar and wind will inherently vary from time to time. The output variation of solar and wind farms will display Wei-bull distribution as a probability density function, and this characteristic is a technically weak point and threat to the supply reliability for power system operations.

Figure 2-12: Wei-bull distribution of renewable energy production

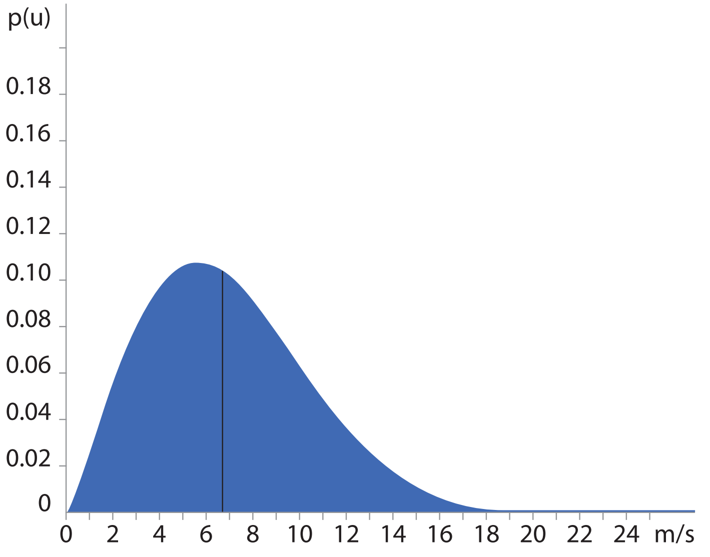
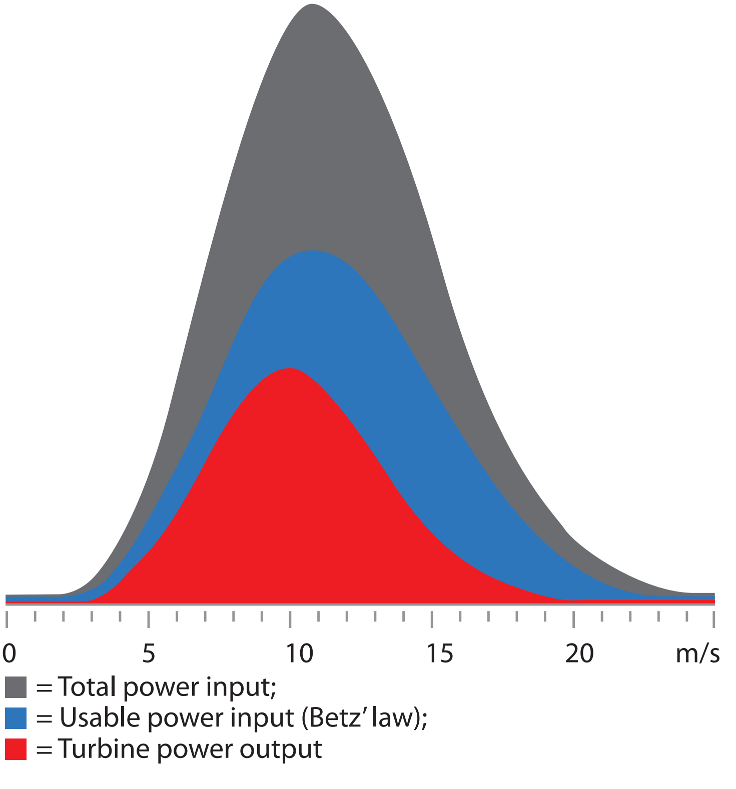


Figure 2-13: Power density function of renewable energy sources



If the renewable energy sources are to adapt to the real power system, the technical requirements needed to compensate for the weak points caused by the inherently technical vulnerable characteristics should be fulfilled. Grid codes will specify this technical requirement which will be satisfied in power system operations. The impacts of increased amounts of renewable energy such as solar and wind power and their technical requirements for installation of renewable production should be studied in detail.[11] To secure a high reliability of supply in the interconnected power system, wind and solar power have to be met with technical requirements. Grid codes determine what is required of power plants when connecting to the network. Grid codes have to define the minimum requirements so that wind generation systems can efficiently produce ancillary services.

In several countries, grid code requirements for wind power plants include a requirement for fault ride in the event of system faults. The fault clearing times as well as the voltage dip requirements and the requirements for providing voltage support during the fault will vary in every grid code. The grid code may also include a requirement for reactive power control. Additional requirements that have to be met when these applications are requested include voltage control, active power and frequency control (e.g. ramp rate control). The ability to adjust the production of renewable energy should be seen as a part of the regulating terms.

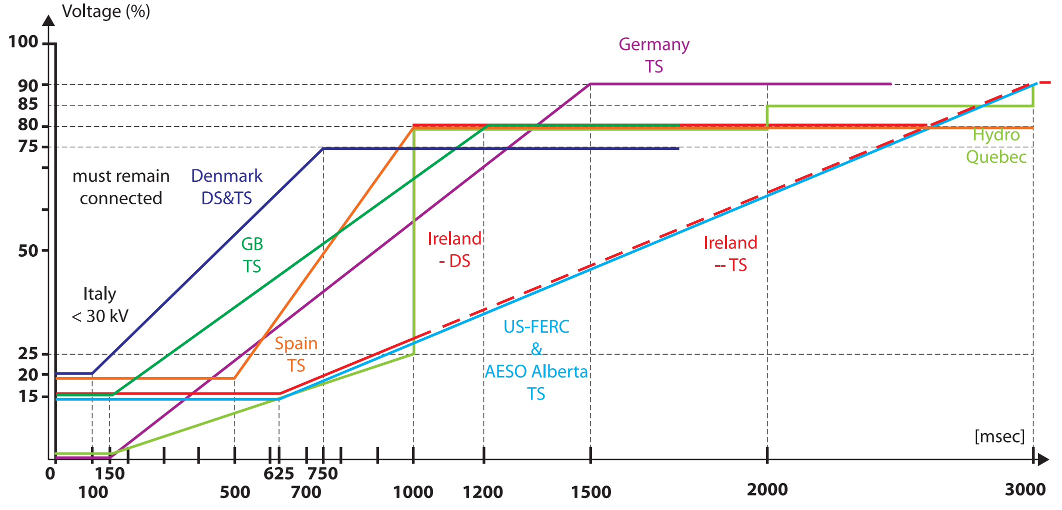
The provision of grid code requirements to maintain the power quality and supply reliability for the application of renewable energy sources implies those technical factors that should be satisfied during power system operations. In general, the technical factors indicated below are specified by the grid code: However, the specific technical parameters of those factors are dependent on the inherent characteristics of each power system.

- FRT (fault ride through) criteria during system fault[12]
- Active power and frequency criteria (normal and emergency status)
- Reactive power and voltage criteria (normal and emergency status)
- Power quality criteria (flicker, harmonics and voltage unbalance ...)
- Communication and data exchange standard
- Protective coordination, etc.

[11] *"Impact of increased amounts of renewable energy on Nordic power system operation", Entso-e, 2010*

[12] *FRT/LVRT/HVRT (fault ride through, low voltage ride through, high voltage ride through) regulation.*

Figure 2-14: Comparisons of FRT criteria for different countries[13]

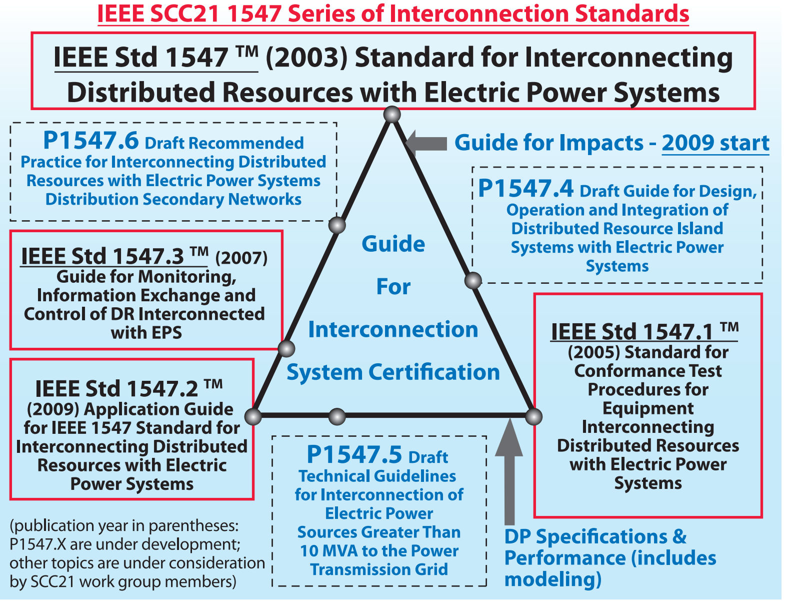


Examples of global standard on power quality for renewable energy output include the institute of electrical and electronics engineers' (IEEE) 1547, IEC 61400 standard. For this IEEE 1547 standard, the main conditions for maintaining system reliability in case of renewable energy resources are as follows:

- IEEE 1547.1 2005 Standard for Conformance Tests Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems
- IEEE 1547.2 Application guide for IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems
- IEEE 1547.3 2007 Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems
- IEEE P1547.4 Draft Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems
- IEEE P1547.5 Draft Technical Guidelines for Interconnection of Electric Power Sources Greater than 10MVA to the Power Transmission Grid
- IEEE P1547.6 Draft Recommended Practice for Interconnecting Distributed Resources with Electric Power Systems Distribution Secondary Networks
- IEEE P1547.7 Draft Guide to Conducting Distribution Impact Studies for Distributed Resource Interconnection

[11] *"Generator Fault Ride Through (FRT) Investigation, Transpower Newzland Lid. 2009.*

Figure 2-15: IEEE Standard 1547 Series

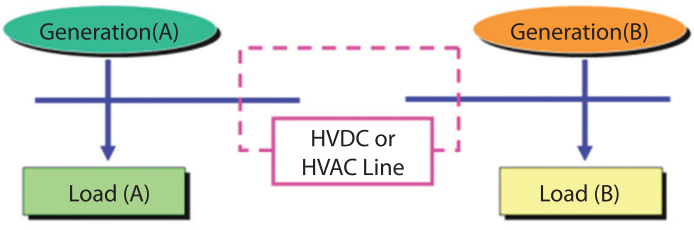


To prevent the negative impacts on power quality and system reliability (as mentioned above), the grid code of the power utility company and related global standards should be adopted in the case of application of renewable energy resources such as solar and wind farms. This grid code application is the same for the Gobitec project.

Interconnection technology and costs for each interconnection option

Electrical energy is secondary energy produced by transforming primary energy sources such as oil, coal, gas, hydro power, or nuclear resources. Electrical energy, by nature, cannot be stored in large-scale capacities and must meet real-time demand and variety of power quality requirements such as frequency, voltage and outage. Therefore, the long-term electrical energy supply plan must consider the economic feasibility, reliability, and environmental impact as laid out by the United Nations framework convention on climate change (UNFCCC). The power system interconnection between countries is one of the possible solutions for long-term electrical energy supply challenges. The international power system interconnection involves constructing interconnected transmission lines between multiple countries and buying or selling stock (power) with each other. This can be a win-win situation for all participants as importing countries secure additional generation resources, and the exporting countries secure power demand.

Figure 2-16: Conceptual diagram of power system interconnection between countries



Power system interconnection technology can be classified into HVAC: AC substation and AC transmission line) and HVDC: DC converter station and DC transmission line). High voltage direct current can be further divided into point-to-point DC (PTP-DC) and back-to-back DC (BTB-DC) depending on whether a DC transmission line is present or not. The PTP method connects DC converter stations located at both ends of the interconnected power system with DC transmission lines. This method is the most appropriate method for long-distance power system interconnections. On the other hand, BTB method has both converter stations in a single location without the DC transmission line. Depending on the type of converter, HVDC can also be subdivided into VSC-DC (voltage source converter DC) and CSC-DC (current source converter DC). Current source converter uses thyristor sets, a current source type power electronic device, and it has been conventionally applied to large-scale capacity HVDC systems.

Current source converter DC requires reactive power compensation at each converter station because its power electronic device lacks self-commutation capability. Therefore, the CSC-DC system has a negative effect on voltage stability of the power system. However, the VSC-DC system uses power electronic devices with self- commutation capability like insulated gate bipolar transistors (IGBT) and gate turn-off thyristors (GTO). This VSC-DC feature has advantages from the viewpoint of reactive power compensation and voltage stability.

Moreover, this feature enables VSC-DC to supply power to areas without local power generation. Unfortunately, current technology is limited to several hundreds of MW only. In the future, VSC-DC technology is expected to advance enough to handle several GW of HVDC interconnections such as power system interconnection between countries.

Figure 2-17: BTB-DC (Back-To-Back DC) DC interconnection

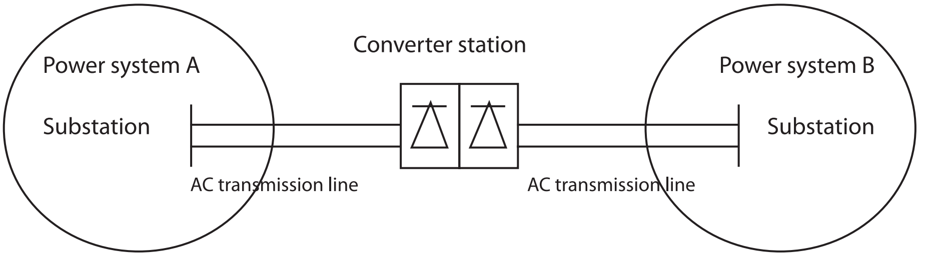
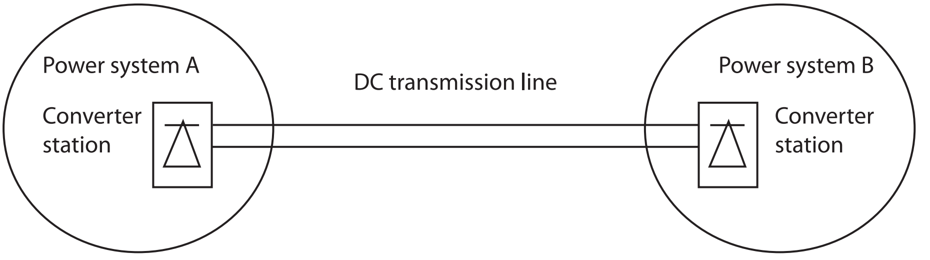


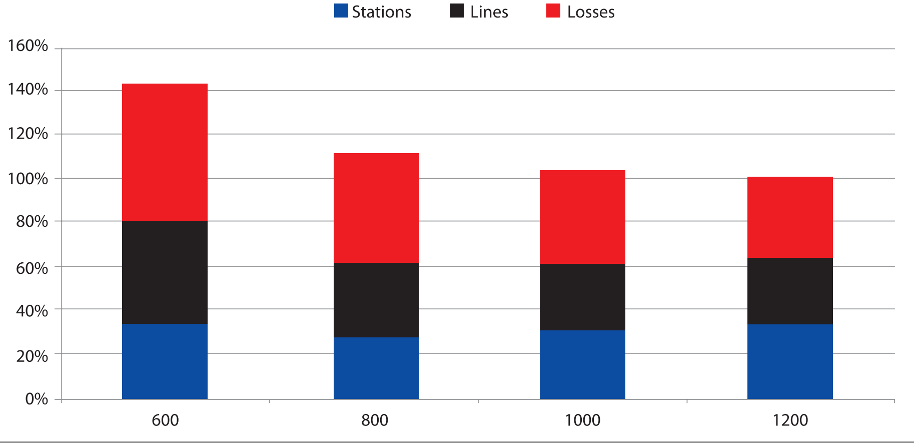
Figure 2-18: PTP-DC (Point-To-Point DC) DC interconnection



When considering the long distance and ultra-high capacity of ASG, HVAC technology cannot be applied, and the study will concentrate on HVDC type technology. However, at this time, the technology that is the more reasonable alternative for ASG cannot be confirmed. Both HVDC technologies have their own advantages and disadvantages. Current source converter-HVDC technology cost is lower than VSC-HVDC, and has fluent experiences and no capacity and voltage limit. In contrast, VSC-HVDC is a source of high technology with excellent power quality and higher system reliability than CSC-HVDC. However, VSC-HVDC has the capacity limit that is lower than a few GW and requires high cost. The ASG, the transmission corridor, will be specified as the HVDC trunk line specification as voltage and capacity for estimated length and technical spec.

The voltage of the cross-border transmission line will be higher than 1000 kV, considering bulk capacity and the long length. This is not sufficient as a ±800 kV UHVDC transmission system for longer than 8 GW and 2000 km cross-border corridors and it may be necessary to construct an even greater line than ±1000 kV UHVDC. China already started the feasibility study and the initial stage R&D for transmitting hydro-generated power of west to east coast load centres above ±1000 kV UHVDC system.[14] Transmitting 8 GW over 2000 km, is comparable to the total transmission costs with voltages. The total cost includes cost for converter substations, overhead lines and the capitalised cost of losses. The results indicate that specific conditions such as overhead line costs and electricity costs can influence the result. However, it is obvious, for a power rating of 8000 MW, moving to higher voltages leads to reduced costs.

Figure 2-19: Optimisation of voltage when transmitting 8000 MW over 2000 km



[14] *Technical Feasibility and Research & Development Needs for ride through) regulationntso-e,R N Nayak; R P Sasmal; Y K Sehgal, CIGRE 2010.*

Table 2-4 gives an approximate optimised voltage level depending on the power rating, considering the cost of power losses. Regarding this table and in consideration of technical viewpoints, the Gobitec transmission corridor should have a voltage higher than a minimum of 1000 kV.

Table 2-4: Optimised voltage (kV) depending on power rating (MW)

Power rating (MW)	Voltage rating (kV)
500	250–350
1000	350–400
2000	400–500
3000	500–600
5000	800–1000
8000 or more	1000–1200

In addition, as a technical opinion and considering the present technology situation, the UHVDC[15] transmission technology for this Gobitec project will be a CSC-HVDC[16] MTDC system, in consideration of a bulk capacity over 10 GW per one TCS and length over 2000 km. However, this technical opinion could be varied in the future because the technical situation and cost parameters may be valid only in the short time.

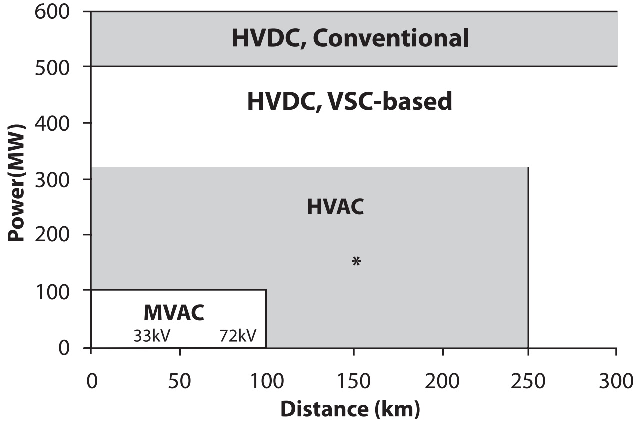
Considering the long duration of this case, the HVAC technology is an impossible alternative because of the loadability and stability for total interconnected power systems between NEA countries. If the HVAC technology is applied in this case, the power system transmittable capacity compared with its rated capacity will decrease as the line length increases over a few hundred km, when the inherent loadability characteristics of HVAC transmission are considered. Also, the stability of the interconnected power system is not guaranteed because of the long HVAC transmission line length. Consequently, in this Gobitec project, the HVAC transmission option is not an applicable alternative from the technical point. This is common sense for the engineering department, so HVAC technology will be an exclusive option.

Although the VSC-HVDC system has a better technical performance for cross-border transmission, the investment cost is high and is limited to lower than a maximum of 1 or 2 GW. Thus, the CSC-HVDC system is a reasonable and practical candidate for Gobitec cross-border transmission.

[15] *UHVDC(Ultra High Voltage Direct Current) means a HVDC system having the voltage above ±800kV.*

[16] *CSC(Current Source Converter) type HVDC system means converter stations with thyristor switching device not having self turn-off characteristic.*

Figure 2-20: Example of HVAC and HVDC technology application[17]



Overall estimated cost for ASG

In general, the purpose of power system interconnection between countries is to seek economic benefit, enhance power system reliability, avoid environmental issues, and promote international energy cooperation. Economic benefits would include providing international power supply/demand and reducing power system operation costs. In general, power system reliability can be accomplished by mutually sharing power reserves. In addition, securing overseas new power sources will reduce the number of domestic thermal power plants; consequently, this reduction will positively impact on CO_2 emissions and mean that each country will make the effort to comply with the UNFCCC environmental requirements.

This section will discuss the cost implications for cross-border interconnection routes, the so-called ASG trunk transmission line that will transmit the Gobitec-generated power to each NEA country. The general technical specifications and overall structures for concept design for this Gobitec and ASG project were already described in an early chapter. In this section the overall annual total power supply unit cost for this project will be estimated; the cost implications will be studied by analysing the components of cost factors and by comparing this total supply unit cost with the electricity charges. We will derive the annual total supply unit cost per kWh, depending on capacity factors (the so-called availability of renewable energy resources). This total supply unit cost includes generation cost for Gobitec solar/wind sources, transmission cost for ASG and connecting cost for each country's power system from the ASG trunk line.

For the cross-border project, the annual total power supply cost means the annual life cycle cost (LCC), which includes both the investment and operation/maintenance costs during the full lifetime of all corresponding power facilities. This concept could also apply for cross-border power trade. This cross-border project is feasible and executable only in the case of an annual total supply when the unit cost is lower than weighted average electricity charges, and in consideration of the distribution share of Gobitec-produced renewable energy for each country.

For the Gobitec and ASG project, annual total supply unit costs will be decomposed into fixed costs and variable costs. Fixed costs include initial investment cost and operation/maintenance costs for the corresponding power facilities such as generation, transmission and

[17] *Transmission options for offshore wind farms in the United States S. D. Wright, A.L. Rogers, J.F. Maxwell, A.E. Ellis*

the other power facilities. Variable costs mainly mean generation fuel costs. The other variable cost is very small compared to the other cost components. Therefore, we can disregard all the remaining variable costs. Fortunately, in terms of a renewable energy source, the fuel cost is meaningless and free of charge, so the full variable cost for this project is zero and it is not necessary to consider this for the cost implications. As a result, we will estimate only fixed costs, by excluding full variable cost.

Fixed cost for our project, in terms of power facility classification, is separated into three categories: Generation cost for Gobitec, transmission cost for ASG and connecting cost to each NEA country. This FC is also divided into construction cost (initial investment cost), operation/maintenance (O&M) cost and additional tax. But, in this study, all the tax components will be neglected.

- Generation costs of solar and wind farms for Gobitec
- Construction and O&M costs of solar farms [$/MW]
- Construction and O&M costs of wind farms [$/MW]
- Collecting cost (subregional and regional transmission to collect the produced solar and wind electricity) for Gobitec-produced renewable energy
- Transmission costs of cross-border corridor for ASG
  - o Construction and O&M costs of ASG cross-border trunk line
- Supplying (connecting) costs to each NEA country
  - o Supplying (connecting) transmission cost from ASG trunk line to each country's power system

Using the above cost components, it is possible to estimate the TSUC for the Gobitec and ASG project and compare this cost with the WAEC, considering each country's weighted average electricity price plus the ASG costs. All the data to estimate the TSUC is given in the tables below. In these tables, red values mean the given data by project coordinator or each country's player and blue values are the calculated parameters by the red data. Practically speaking, it is a very complex study to obtain this given data and it should be revised in the future. In addition, this data will vary from case to case, depending on each country and the power system's condition, so a sensitivity check should be performed depending on these data variations in the future. An Excel sheet will simplify this full calculation and perform this sensitivity check using data variations by providing information through each country's players. This chapter will explain in detail the calculation data and the total TSUC estimation procedures as below.

At first, Table 2-5 gives the basic data to calculate the capital recovery factor (CRF) and finally TSUC for this project. In this table, the life cycle period of all renewable plants is presumed as 30 years. Also, in economic assessment, it is necessary to consider the interest rate (%) regarding the degrading of money value or the internal rate of return. Every generation plant needs to generate a power supply for electricity within that corresponding plant site, so the energy consumption ratio (%) inside the plant will be displayed as the ratio of the total generation amounts (TWh/Year). In addition to the energy consumption ratio within the plant, the transmission and distribution (T&D) loss ratio (%) means the total summation of transmission loss to cross-border power trade through ASG.

Table 2-5: Basic data for Gobitec solar/wind energy

Source Type	Capacity (MW)	Life period n (year)	Interest i (%)	Energy Consumption Ratio within Plant (%)	T&D* loss ratio (%)
Solar Farms	50,000	30	5%	0.5%	7%
Wind Farms	50,000	30	5%	0.5%	7%

*= *transmission and distribution*

The total renewable energy produced by solar and wind sources in the Gobi Desert will be distributed for each country through cross-border transmission lines through the ASG. Table 2-6 specifies the distribution share (%) of total generation amounts transmitted to each country. Basically, Russia has a negative value: This means Russia is an electricity exporting country to neighbouring economies through the ASG.

$$(100 + \text{RUSSIA})\% = (\text{MO}) + (\text{CH}) + (\text{KO}) + (\text{JP})\% \qquad \text{eq. 1}$$

Table 2-6: The distribution share (%) of total generation amount

Country	Total	MONGOLIA	Russia	China	Korea	Japan
Distribution Share (%)	100.0%	1.0%	-3.0%	81.0%	5.0%	10.0%

The capital recovery factor (CRF) is the ratio of annual recovery cost to the total investment cost and this CRF value can be calculated from the interest rate and life period. The equation to calculate CRF is shown in eq. 2.

$$CRF = \frac{i * (1 + i)^n}{(1 + i)^n - 1} \qquad \text{eq. 2}$$

Fixed cost ratio (FCR) means the ratio of the annual fixed charge to the total investment cost and is the sum of the CRF (%), O&M (%) and Tax (%). In general, the O&M cost is also given by the ratio of total annual O&M cost to the total investment cost. In this study, all the tax will be neglected.

$$\text{FCR}(\%) = \text{CRF}(\%) + \text{OM}(\%) + \text{TAX}(\%) \qquad \text{eq. 3}$$

Table 2-7: Annual FCR (%) calculation sheet

Source Type	CRF(%)	O&M(%)	TAX(%)	FCR(%)
Solar Farms	6.51%	2.50%	0.00%	9.0051%
Wind Farms	6.51%	2.50%	0.00%	9.0051%

Table 2-8 describes the overall calculation procedures for the estimation of TSUC and WAEC. In this table, the TSUC ($/kWh) is calculated by the function of the capacity factor for Gobitec's entire solar and wind farms. This capacity factor means the availability of total generators and is equivalent to the weighted average annual availability of total solar and wind farms. In this study, considering both the characteristics of renewable energy and the prevailing desert conditions, the annual weighted average availability (%) as 30% in both solar and wind farms is presumed, but the cost implication analysis will be done depending on the availability variation. Using this weighted average availability (%) and total solar and wind capacity, the average power (MW) by eq. 4 can be calculated.

$$(\text{Avarage Power [MW]}) = (\text{Capacity[MW]}) * (\text{Weighted Average Availability [\%]}) \qquad \text{eq. 4}$$

Using this average power [MW] data, the annual generation energy amounts (TWh/Year) by eq. 5 can be calculated.

$$(\textit{Annual Generation Amount}\ [\textit{TWh/Year}]) = (\textit{Average Power}\ [\textit{MW}]) * 365\ \textit{day} * 24\ \textit{hours} * 10^{-6} \qquad \text{eq. 5}$$

Also, the annual sales energy amount (TWh/Year) means the practical commercial sales electricity, so this is the value of annual generation amount (TWh/Year) minus energy consumption ratio (%) within the generation plant minus the transmission loss ratio (%).

$$(\textit{Annual Sales EnergyAmount}\ [\textit{TWh/Year}]) = (\textit{Annual Generation Amount}) * (1 - A - B) \qquad \text{eq. 6}$$

where, A = energy consumption ratio (%) within generation plants

B = transmission loss ratio (%)

The annual fixed charged cost (million$/Year) is calculated by the multiplication of FCR (%) and total investment cost ($) including the cost for the Gobitec project, ASG and connecting cost for each country as well as the O&M cost. Total investment cost means the construction cost and will be explained in Table 2-8.

$$(\textit{Annual Fixed Charged Cost}\ [\textit{Million \$/Year}]) = \textit{FCR}(\%) * \textit{Total Investment Cost}\ (\$) + \textit{O\&M Cost}\ (\$) \qquad \text{eq. 7}$$

As mentioned above, in this study there is no variable cost; the so-called fuel cost, in the case of the renewable energy source because the fuel from nature will be supplied permanently. Consequently, TSUC ($/kWh) is derived by eq. 8 and is the value of annual fixed charged cost ($) plus annual variable cost ($) divided by annual sales energy amount (TWh/Year). This TSUC data has the same meaning as the electricity charge of exporting countries.

$$(\textit{Total Supply Unit Cost } [\$/kWh]) = \frac{B}{A} \qquad \text{eq. 8}$$

Where A : Annual sales energy amount (TWh/Year)

B : Annual fixed charged cost ($) + annual variable cost ($)

In reality, the table below is the comparison of the TSUC with the WAEC. In this table, TSUC is the total supplying unit cost and is composed of the total annual investment and O&M cost; while WAEC is the summation of the costs of each country's average electricity tariff and the total ASG cost, depending on capacity factor.

WAEC = (*Weighted Average Electricity Charge of each country considering Share of GOBITEC power*) + (*Total ASG cost per transmitting kWh*)

The electricity charge of each country is given in Figure 2-21 and the WAEC ($/kWh) is the weighted average electricity charge, considering the distribution share (%) for each country. In contrast to TSUC ($/kWh), this WAEC means the average electricity charge of importing countries plus the total ASG costs per kWh depending on the capacity factor. Finally, the differences between the WAEC ($/kWh) and the TSUC ($/kWh) will be calculated, depending on various capacity factors. The Gobitec project will be a beneficial business where there is a positive value of this difference (WAEC–TSUC). Generally speaking, TSUC ($/kWh) will decrease with the increase of the capacity factor, so this project will be a good alternative in the presence of a high capacity factor.

Figure 2-21: Comparison of TSUC (total supply unit cost) and WAEC (weighted average electricity charge) with different capacity factors

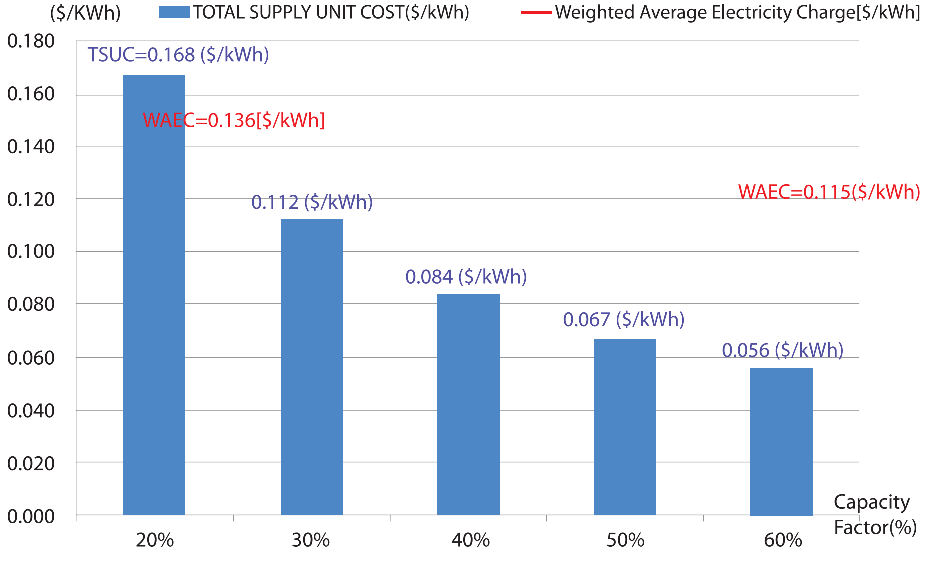


Table 2-8: Estimation of total supply unit cost and comparison with each country's electricity charge

ITEM	CAPACITY_FACTOR(AVAILABILITY) OF RENEWABLE ENERGY (SOLAR+WIND FARMS)				
Weighted Average Availability (%) (Solar+Wind)	20%	30%	40%	50%	60%
AVERAGE POWER(MW)	20,000	30,000	40,000	50,000	60,000
ANNUAL GENERATION ENERGY AMOUNT (TWh/Year)	175.20	262.80	350.40	438.00	525.60
ANNUAL SALES ENERGY AMOUNT (TWh/Year)	162.06	243.09	324.12	405.15	486.18
ANNUAL FIXED CHARGED COST (Million$/Year)	32,402	32,402	32,402	32,402	32,402
ANNUAL VARIABLE(Fuel) COST (Million$/Year)	0	0	0	0	0
TOTAL SUPPLY UNIT COST ($/kWh)	0.200	0.133	0.100	0.080	0.067
Electricity Charge MONGOLIA	0.112	0.112	0.112	0.112	0.112
RUSSIA	0.090	0.090	0.090	0.090	0.090
CHINA	0.110	0.110	0.110	0.110	0.110
KOREA	0.100	0.100	0.100	0.100	0.100
JAPAN	0.113	0.113	0.113	0.113	0.113
Weighted Average Electricity Charge	0.136	0.125	0.120	0.117	0.115
Differences b/t weighted average electricity charge and total supply unit cost	-0.032	0.013	0.036	0.050	0.059

Table 2-9 represents the total investment cost ($): The calculation sheet outlines the construction of the whole Gobitec generation site, including the entire collection system, and the ASG-TOTAL of each country's connecting system. The initial investment cost is composed of two parts: One is the original construction cost of PV and wind plants; the other represents the additional costs for the power conditioning system (PCS) (including ESS) and additional thermal plants in order to compensate for the vulnerable characteristics of renewable energy sources.

All these data calculations are derived from the table indicated below. All data used in this study is not corrected or confirmed data; it is based on corresponding references and engineering concepts. This is a preliminary study, so a more detailed study will be necessary for data identification in order to perform future pre-feasibility and feasibility studies.

Table 2-9: Calculation sheet for total construction investment cost ($)

ITEM	CONSTRUCTION COST [M$]	ANNUAL O&M COST [M$/Year]
GOBITEC	237,900	5,948
ASG-TOTAL	56,709	1,418
(ASG+GOBITEC COLLECTING SYSTEM)	34,562	864.0
(MONGOLIA SIDE CONNECTING SYSTEM)	235	5.9
(RUSSIA SIDE CONNECTING SYSTEM)	666	16.7
(CHINA SIDE CONNECTING SYSTEM)	16,750	418.8
(KOREA SIDE CONNECTING SYSTEM)	1,476	36.9
(JAPAN SIDE CONNECTING SYSTEM)	3,021	75.5
SUM	294,609	7,365

First, total construction cost [M$] for the Gobitec solar and wind farms is calculated by the multiplication of total construction capacity [MW] and unit construction cost [$/MW]. Also, the O&M cost (%) for Gobitec is given by the ratio to the total construction cost (M$).

Table 2-10: Construction and O&M cost for Gobitec

Construction Capacity of Solar Farms [MW]	50,000	Construction Capacity of Wind Farms [MW]	50,000
Construction Cost of Solar Farms [$/MW]	1,960,000	Construction Cost of Wind Farms [$/MW]	1,700,000
Additional cost for PV (PCS or Complementary plants)	588,000	Additional cost for Wind (PCS or Complementary plants)	510,000
O&M Cost(%) of solar farms [% of total investment cost/year]	2.5%	O&M Cost of Wind farms [% of total investment cost/year]	2.5%
TOTAL GOBITEC CONSTRUCTION COST: 237,900 M$ GOBITEC ANNUAL O&M COST [M$/Year] 5,948 [M$/Year]			

Secondly, the cost for cross-border transmission and collection to the ASG main station for the electricity collection of solar and wind farms will be calculated. These costs also include both construction and O&M cost (Table 2–10).

Table 2-11 is the cost calculation sheet for the ASG plus collecting system and includes both the construction and O&M costs. In this table, collecting and sub-transmission system costs for the total solar and wind farms will be given by the percentage of total Gobitec construction cost. Also, for satisfying the (N-1) criteria to guarantee reasonable power system supply reliability, the C/S (Converter Station) and transmission circuit capacity per bipole will have some margin as eq. 9 shows. If the system is designed by satisfying (N-1) criteria, it can be safely operated when one of the bipoles or transmission circuits are faulted during normal system operations.

$$\textit{Capacity of Cross – border C/S per bipole } [MW/(bipole)] = \frac{1}{(N-1)} * \frac{(S+W)}{N} \qquad \text{eq. 9}$$

where N = Number of Bipoles or Transmission Circuits

S = Total Capacity of Solar Farms [MW]

W = Total Capacity of Wind Farms [MW]

The total system loss is divided into two parts: ASG C/S and transmission loss. In this study, among the above total T&D loss ratio (%), the C/S loss is assumed as 30% and the rest (70%) is for transmission loss.

Table 2-11: Cost calculation sheet for ASG plus collecting system

Collecting & Sub-transmission Costs within solar farms[% of Solar Farms Construction cost]	5.0%	Collecting & Sub-transmission Costs within Wind farms[% of Wind Farms Construction cost]	5.0%
O&M Cost for Collecting & Sub-transmission system within solar farms[% of Investment]	2.5%	O&M Cost for Collecting & Sub-transmission system within wind farms[% of Investment]	2.5%
HVDC Transmission Voltage[Kv]	1,000	Total Capacity of Cross-border System [MW]	133,333
No. of HVDC bipole	4	No. of HVDC transmission Circuits	4
Loss of C/S[% of Capacity/Bipole]	2.1%	Loss of Transmission Line[%]	4.9%
Capacity of Cross-border C/S per bipole [MW/bipole]	33,333	Total transmission Length[km]	3,000
Construction cost of C/S[$/MW]	170,000	Construction cost of cross-border T/L per tower[$/tower-km]	
O&M Cost for C/S [% of construction cost]	2.5%	O&M cost for T/L [% of construction cost]	2.5%
TOTAL ASG+COLLECTING SYSTEM CONSTRUCTION COST: 34,562 M$ ASG+COLLECTING SYSTEM ANNUAL O&M COST [M$/Year] 864 [M$/Year]			

The ASG is connected with five Asian countries – Mongolia, Russia, China, Korea and Japan, and these countries should construct the necessary connecting transmission system from ASG trunk system with their own domestic power system for cross-border electricity trade. The five tables indicated below describe each country's data on connecting system costs and electricity charge data (almost the same procedures as explained in Table 2-11).

Table 2-12: Mongolia side connecting cost sheet

Electricity Charge[$/kWh]	0.120	Availability[%]	
HVDC Transmission Voltage[Kv]	1,000	Total Capacity of Connecting T/L to each country's power system[MW]	1,000
No. of HVDC bipole	1	No. of HVAC transmission Circuits	1
C/S Capacity per bipole [MW/bipole]	1,000	Total transmission Length[km]	430
Construction cost of C/S per bipole[$/MW-Bipole]	170,000	Construction cost of connecting AC T/L per C-km[$/C-km]	1500,000
O&M Cost for C/S [% of construction cost]	2.5%	O&M Cost for AC T/L [% of construction cost]	2.5%
		HVAC Transmission Voltage[Kv]	500
TOTAL MOGOLIA SIDE CONSTRUCTION COST: 235 M$ ANNUAL O&M COST [M$/Year] 5.9 [M$/Year]			

Table 2-13: Russia side connecting cost sheet

Electricity Charge[$/kWh]	0.100	Availability[%]	
HVDC Transmission Voltage[Kv]	1,000	Total Capacity of Connecting T/L to each country's power system[MW]	3,000
No. of HVDC bipole	1	No. of HVAC transmission Circuits	1
C/S Capacity per bipole [MW/bipole]	3,000	Total transmission Length[km]	520
Construction cost of C/S per bipole[$/MW-Bipole]	170,000	Construction cost of connecting AC T/L per C-km[$/C-km]	300,000
O&M Cost for C/S [% of construction cost]	2.5%	O&M Cost for AC T/L [% of construction cost]	2.5%
		HVAC Transmission Voltage[Kv]	1,000
TOTAL RUSSIA SIDE CONSTRUCTION COST: 666 M$ ANNUAL O&M COST [M$/Year] 16.7 [M$/Year]			

Table 2-14: China side connecting cost sheet

Electricity Charge[$/kWh]	0.150	Availability[%]	
HVDC Transmission Voltage[Kv]	1,000	Total Capacity of Connecting T/L to each country's power system[MW]	81,000
No. of HVDC bipole	4	No. of HVAC transmission Circuits	4
C/S Capacity per bipole [MW/bipole]	20,250	Total transmission Length[km]	745
Construction cost of C/S per bipole[$/MW-Bipole]	170,000	Construction cost of connecting AC T/L per C-km[$/C-km]	500,000
O&M Cost for C/S [% of construction cost]	2.5%	O&M Cost for AC T/L [% of construction cost]	2.5%
		HVAC Transmission Voltage[Kv]	1,000
TOTAL RUSSIA SIDE CONSTRUCTION COST: 16,750 M$ ANNUAL O&M COST [M$/Year] 418.8 [M$/Year]			

Table 2-15: Korea side connecting cost sheet

Electricity Charge[$/kWh]	0.120	Availability[%]	
HVDC Transmission Voltage[Kv]	1,000	Total Capacity of Connecting T/L to each country's power system[MW]	5,000
No. of HVDC bipole	2	No. of HVAC transmission Circuits	2
C/S Capacity per bipole [MW/bipole]	2,500	Total transmission Length[km]	1,160
Construction cost of C/S per bipole[$/MW-Bipole]	170,000	Construction cost of connecting AC T/L per C-km[$/C-km]	270,000
O&M Cost for C/S [% of construction cost]	2.5%	O&M Cost for AC T/L [% of construction cost]	2.5%
		HVAC Transmission Voltage[Kv]	765
TOTAL RUSSIA SIDE CONSTRUCTION COST: 1,476 M$ ANNUAL O&M COST [M$/Year] 36.9 [M$/Year]			

Table 2-16: Japan side connecting cost sheet

Electricity Charge[$/kWh]	0.141	Availability[%]	
HVDC Transmission Voltage[Kv]	1,000	Total Capacity of Connecting T/L to each country's power system[MW]	10,000
No. of HVDC bipole	3	No. of HVAC transmission Circuits	3
C/S Capacity per bipole [MW/bipole]	3,333	Total transmission Length[km]	1,420
Construction cost of C/S per bipole[$/MW-Bipole]	170,000	Construction cost of connecting AC T/L per C-km[$/C-km]	310,000
O&M Cost for C/S [% of construction cost]	2.5%	O&M Cost for AC T/L [% of construction cost]	2.5%
		HVAC Transmission Voltage[Kv]	1,000
TOTAL RUSSIA SIDE CONSTRUCTION COST: 3021 M$ ANNUAL O&M COST [M$/Year] 75.5 [M$/Year]			

Conclusions

This chapter specifies the whole technical concept and cost implications for the Gobitec and ASG project. The methodology used in the interconnection of this complex system for each country's power system is also described; in addition, the impacts of the Gobi renewable energy resources on power system reliability and grid code application countermeasures are explained. Finally, in the technical and economical sense, the supply unit cost is estimated: TSUC [$/kWh] for the Gobitec and ASG project and this TSUC value is compared with the WAEC value.

- From a technical viewpoint, considering the long-distance and large-scale power transmission, the HVDC system is a more appropriate alternative to the HVAC. However, it was not possible to confirm or determine which type of HVDC technology (between VSC, CSC or HVDC) is the more appropriate for ASG.
- As everybody knows, the electricity output of renewable energy sources has vulnerable characteristics and can threaten the reliability of the power system. Therefore, for stable and reliable power supply, a grid code should be applied to power system operations for the Gobitec and ASG project.
- In addition, this paper calculates the TSUC charges for Gobitec exporting countries and WAEC for importing parties. The difference between WAEC and TSUC means the commercial benefits gained through cross-border electricity trade by way of the ASG. As a result of cost implications, Gobitec plus ASG can be a commercially positive project, but much depends on the capacity factor. This preliminary study shows that this project can be a beneficial business if the capacity factor is greater than at least 30%. However, all such data should be confirmed because the correctness of the data used in this study could not be guaranteed. If, however, some data is changed, study results will need to be amended and then the project could be of a non-beneficial business. Consequently, the project results are sensitive to changes in data.

- Finally, as mentioned above, all the data used in this study is not flawless or confirmed; it is based on references and engineering concepts. This is only a preliminary study; therefore, a more detailed study will be necessary for data identification in order to perform future pre-feasibility and feasibility studies.

THE LEGAL FRAMEWORKS

Promoting investments in regional energy market

The provision of reliable and affordable energy services is a prerequisite for economic and social development. Infrastructure such as electricity generation facilities and transmission networks are crucial for the efficiency, competitiveness and growth of economies for countries in the NEA region.

Moreover, there is increasing global demand for investments in infrastructure, creating competition for investment among many countries around the world. Many countries are seeking to create a favourable business environment that is acceptable to investors; some countries are actively promoting foreign investment in infrastructure.

In general, infrastructure investments tend to be highly capital intensive, have long gestation periods and strong government involvement. Accordingly, the potential risks associated with such investments are a matter of concern for foreign investors. The combination of high commercial risk and a weak regulatory and institutional environment in a host country can effectively block the inflow of foreign investment, especially in countries with relatively small domestic markets.

Many regions around the world are interested in new regional, bilateral, or multilateral approaches that direct attention to better coordination of their efforts in order to create more robust regional power grids with the potential of lowering capital investment requirements across time and reducing system operational costs.

To facilitate the considerable investment required for realisation of Gobitec and ASG industrial initiates, the countries in the region shall actively work to attract foreign investors through an attractive business climate in the region and across the borders.

Foreign direct investment has the potential to generate employment, raise productivity, transfer skills and technology, enhance exports, and contribute to the long-term economic development of the world's developing countries. In general, private investment allows governments to redirect funds to other uses and public needs. Foreign direct investment in the energy sector compensates for deficiencies in local capital markets. At the same time, it provides access to advanced technology, know-how and production techniques, as well as advanced management techniques.

In order to attract FDI, governments can provide information about existing investment opportunities, assisting with approval processes and facilitating investment. An important consideration for potential investors is a country's political and economic stability. Companies may also evaluate other market, financial and legal risks. The main areas are market access, including market structure, discrimination and bureaucracy and market operations, including legal framework, the financial environment and market conditions.

In recognising the importance of renewable energy in addressing climate change and energy security, some countries in NEA have undertaken a number of policy drivers to increase the use of renewable energy. China, Japan, and the Republic of Korea have relatively comprehensive renewable energy policies, while Mongolia and the Russian Federation have adopted fewer policy mechanisms for renewable energy development.

Table 3-1: Renewable Energy Support Policies in Japan, South Korea, China and Mongolia

Renewable Energy Support Policies		Japan	Republic of Korea	China	Mongolia
Regulatory Policies and Targets	Renewable energy targets		●	●	●
	Feed-in tariff/ premium payment	●		●	●
	Electric utility quota obligation/ RPS*		●	●	
	Net metering	●	●		
	Biofuels obligations/ mandate		●	●	
	Heat obligation/ mandate			●	
	Tradable REC**	●	●		
Fiscal Incentives	Capital subsidy, grant, or rebate	●	●	●	
	Investment or production tax credits	●	●		
	Reductions in sales, energy, CO2, VAT, or other taxes		●	●	
	Energy production payment			●	
Public Financing	Public investment, loans, or grants	●	●	●	
	Public competitive bidding/ tendering			●	●

Note: ● indicates national level policy, Japan ended RPS in 2012.
Source: (REN21, 2013, pp. 80–82)
** RPS = renewable portfolio standards; ** REC = renewable energy certificates*

A recent study "Global Trends in renewable energy investment 2013"[18] states that investment in renewable power and fuels (including small hydroelectric projects) was $ 244 billion in 2012 with a further shift in activity from developed, to developing economies. China was the dominant country in 2012 for investment in renewable energy, its commitments rising 22% to $ 67 billion due to a jump in solar investment. Japan also saw investment in renewable energy (excluding research and development) surge 73% to $ 16 billon due to a boom in small-scale PV on the back of new feed-in tariff subsidies for solar installation.

Analysis of global trends in the renewable energy sector shows that the main issue holding back investment in 2012 was instability in the policy regime for renewable energy in importantly developed economy markets. It is important for countries in the NEA region to consider European experience and carefully adopt policy measures aimed at increasing production from renewable energy, minimise costs and deliver job creation.

Assessment of trade legislation related to energy sector

International law related to trade of electricity

Liberalisation of the electricity industry and the introduction of competition have more recently led countries to the recognition of the relevance of the World Trade Organisation (WTO) and ECT rules in relation to trade of electricity across borders.

The WTO and ECT rules discipline governmental policies and measures affecting trade. "Governments" and "measures" have a broad meaning and in general include any measures,

[18] *Frankfurt School –UNEP Collaborating Centre for Climate and Sustainable Energy Finance.*

such as laws, regulations, judicial decisions, administrative practices, governmental decisions, relevant to the operation of the WTO agreements. Electricity as a commodity is fully subject to the 1994 provisions of general agreement on tariffs and trade (GATT) and other WTO agreements on goods.[19]

As a consequence, the automatic and unconditional most-favoured national (MFN) treatment obligation on GATT Article I, and the national treatment (NT) obligation in GATT Article III fully apply to trade in relation to electricity.

The MFN provisions contained in GATT imply that, with respect to any measure imposed on the import or export of electricity, any advantage or privilege accorded to one country should be extended to electricity imported from or exported to any other country, and that no reciprocal conditions may be attached to such granting.

The provisions of GATT Article III impose constraints on governments with respect to internal taxation and any other internal regulations concerning the sale, purchase, use or transportation of electricity; they also prohibit any discrimination between domestic and imported electricity.

A further important obligation under GATT is the prohibition of quantitative restrictions on imports and exports of electricity. This means that governments may not use policy instruments to regulate imports or exports, other than when customs duty tariffs are imposed on goods.

Some legal rules are applicable to regional markets: GATT Article XXIV permits contracting parties to deviate from the non-discrimination (MFN) obligations if they grant preferential treatment for their trading partners in the framework of a customs union or of the free-trade area of member countries. However, there are strict conditions attached to such preferential treatments. One of the conditions of customs unions or regional trade agreements (RTA) is that under the RTA restrictions, area members should be removed for "substantially all the trade" and – in the case of customs unions – the protection imposed against imports from other countries should not be increased.

At present, countries in NEA actively establish free-trade area agreements (FTAs). The large economies of China, Japan and the Republic of Korea have taken a lead in forging FTAs with trading partners in the region and around the world. In general FTAs cover industrial products and do not exclude electrical energy. Furthermore, these RTAs do not seem to grant any special treatment to electrical energy relative to other products. Consequently, trade in electricity – from a legal viewpoint – is deemed totally free of any trade restrictions.

Trade barriers in electricity sector

Compared to other economic sectors, the electricity sector is highly regulated; barriers to trade in many instances do not result from the application of trade policy instruments, but from domestic regulatory policies, such as product regulations, network access conditions, and public service obligations.

These measures have the explicit objective of influencing or interfering with cross-border dealings between exporters and importers of electricity. Examples are: Import tariffs, discriminatory or discretionary authorisation (licensing) procedures, network access barriers, reciprocity requirements, and explicit trade restrictions, whether or not discriminatory. The following is a list of tentative conclusions concerning the obstacles to trade:

[19] *Since the obligations under the WTO and the ECT are substantially the same, any reference in this paper to a GATT/WTO provision is to be taken as a reference to the corresponding obligation under the ECT.*

- An industry structure represented by a vertically integrated national monopoly, with full or predominant State-ownership, is itself a barrier to trade in electricity and seems to be the most trade-restrictive among all barriers;
- A somewhat less trade-restrictive power sector structure is when generation and distribution is open to private participation or fully private ownership, while the national transmission company retains full monopoly over purchases from producers and sales to distribution companies;
- A great number of product regulations, which aim at promoting electricity produced from renewable energy sources or with specified technologies, may involve discrimination against foreign electricity;
- A crucial issue for fully liberalised markets is the terms and conditions of access to the transportation network. The absence of non-discriminatory, transparent and predictable conditions of network access in itself renders full trade liberalisation illusory.

State-trading

Import monopolies and State-trading enterprises traditionally have been prevalent in the electricity supply sector in many regions of the world including NEA. Despite progressive liberalisation of the sector, State-trading is still present in this region.

In Mongolia, the Republic of Korea and China vertically integrated firms with monopoly rights in their respective areas (in most cases on the whole national territory, or in designated areas) buy from generators and distribute and sell to customers; also, they import or export electricity – a process which constitutes "State-trading" within the meaning of GATT Article XVII. With regulatory reforms of the electricity supply industry and progressive liberalisation of one or more segments of the electricity business, State-trading may no longer characterise the former incumbents or new entrants.

General agreement on tariffs and trade does not prohibit State-ownership of trading entities or import monopolies or other forms of State-trading. Rather it ensures that if such organisations exist, they abide by the obligations and the market access commitments that their governments have subscribed to. Within the NEA area, the most widespread form of State-trading appears to be:

- Monopoly rights given to one single State-owned company to operate all segments of the industry, from generation to supply;
- Network operators designated to purchase electricity from specified generators and resell it to distributors;
- Area monopoly rights granted to suppliers in their respective areas; within partial liberalisation: Designation of one body as "single buyer";
- Trade between producers and distribution companies to be subjected to the agreement of the network operator;
- Import and export monopoly rights.

Government ownership is not the sole and decisive criterion in identifying State-trading enterprises. It is not ownership per se that matters, but the extent to which any organisation has been bestowed with exclusive or special rights by the government. Though it is the operation, rather than the ownership of the enterprise, which determines whether a given entity is a State-trading enterprise, the links between governments and the enterprises they own may be such as to create a hidden barrier to trade.

Access to network

The elimination of all possible physical, trade and regulatory barriers is in itself not sufficient to ensure the liberalisation of the electricity market. To ensure effective electricity trading in NEA, it is necessary to put in place new regulatory mechanisms aimed at ensuring, among other things, access to networks.

Electricity trade is par excellence network-dependent; without free access by electricity producers, traders and consumers of transportation facilities and trade liberalisation measures may not function effectively. Free cross-border trade in electricity requires that T&D grids and cross-border interconnections be opened by operating companies to all market players on non-discriminatory, transparent and predictable terms.

Because T&D remain the natural monopolies, an effective access for importers/exporters to pre-existing transportation facilities needs to be secured through pro-competitive regulations that ensure third parties have the right to use such facilities on the basis of fair sharing of capacities, for a reasonable fee and on practical technical terms. Third-party access (TPA) is, therefore, important not only for creating competitive national electricity markets, but also for ensuring undistorted cross-border trade. Nevertheless without TPA, electricity trade is possible and could be administered under the ECT.

It should be noted that the ECT's provisions[20] do not:

(i) oblige any contracting party to introduce mandatory TPA; or

(ii) prevent the use of pricing systems which, for particular consumers, can apply identical prices to customers in different locations.

Overview of cooperation platforms and international organisations of NEA

Regional cooperation platforms

The advantages of a regional approach to the supply of electricity could be estimated in technical, commercial, but also in political terms. A regional approach would benefit from a common legal framework to guarantee investment and to ensure the development of the cross-border trade in electricity. The promoting of Gobitec and ASG initiatives requires a strong political and legal framework to allow the countries with different energy market models to jointly develop large-scale infrastructure projects.

The geographical proximity of the NEA countries together with a shared understanding of the above mentioned energy challenges was expected to lead to collaboration on energy trade, investment and a sustainable development agenda, despite their diversity in energy production and consumption patterns. However, regional attempts to build effective energy cooperation in NEA have faced a number of economic and geopolitical constraints so far.[21]

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[20] *ECT, Understandings, 1 (b), page 25.*

[21] *Lee, Jae-Seung (Korea University), Yu, Jungmin (Anyang University), North-East Asian Perspectives on the Challenges to Energy Security and the Sustainable Use of Energy, 2013.*

The countries of the NEA region have implemented several energy-related initiatives and programs at regional level; these programs deal with such issues as fossil fuel, electric power, renewable energy and energy efficiency. Table 3–2 shows several initiatives for energy cooperation that have been implemented in the region with different levels of success.

Table 3-2: Initiatives for energy cooperation in Northeast Asia

Initiatives	Related countries	Objectives
ECNEA (Intergovernmental collaborative mechanism on cooperation in North-East Asia)	Russia, Mongolia, South Korea, North Korea	(1) To increase supply of energy in NEA; (2) To build integrated grid system in NEA; (3) To optimise economy and efficiency of supply and use of energy; (4) To minimise the environmental impact of energy production and energy consumption through improved energy mix and greater energy efficiency.
TAES (Trans-Asia Energy system)	ESCAP member States	The objective of the TAES is to promote enhanced energy security through greater coordination and integration of the regional energy system for energy exchange and trade in support of sustainable development.
Korea-China-Japan Trilateral Energy dialogue	Korea, China, Japan	Joint statement "Cooperation towards Sustainable Growth" calls to commence research or consultation in the area of sustainable growth including renewable energy and energy efficiency.
Five-Country Energy Ministers meeting	China, Japan, the United States, India, the Republic of Korea	1) transparency, predictability and stability of global energy markets, 2) improving the investment climate in the energy sector, 3) enhancing energy efficiency and energy saving, 4) diversifying energy mix, 5) securing critical energy infrastructure, 6) reducing energy poverty, and 7) addressing climate change and sustainable development.

Source: Lee, 2010 and research by the Energy Charter Secretariat (ECS)

Of the four major regional initiatives on energy cooperation, only the ECNEA involves all countries of the NEA that could jointly realise the Gobitec and ASG initiatives. The committee on energy cooperation in NEA meets on a regular basis to discuss progress of the implementation of the ECNEA. The committee aims to further deepen the understanding of the recent national energy agenda and policy measures, with the focus on the recent developments in the national energy policies in the member countries of the ECNEA. At the last meeting in 2013, the Ministry of Energy of Mongolia noted that it intends to facilitate the International Forum on Renewable Energy, Energy Cooperation and Grid Integration with the objectives: (1) To increase supply of energy in NEA; (2) To build an integrated grid system in NEA; (3) To optimise the efficiency of supply and use of energy; and (4) To minimise the environmental impact of energy production and energy consumption through an improved energy mix and greater energy efficiency.

International organisations of NEA

A number of international organisations are involved in the regional cooperation on energy. At the regional level, these include APEC, ADB, ESCAP, the EC and other stakeholders.

Asia–Pacific Economic Cooperation (APEC)

Asia–Pacific Economic Cooperation plays an important role in pursuing green growth in the region. It has 21 members referred to as 'member economies'. The term 'member economies' is used because the APEC cooperative process is predominantly concerned with trade and economic issues, with members engaging with one another as economic entities.

Asia–Pacific Economic Cooperation recently adopted a list of environmental goods that directly and positively contribute to APEC's green growth and sustainable development objectives on which applied tariff rates will be reduced to 5% by the end of 2015. It is considered that trade and investment liberalisation in environmental goods will help APEC businesses and give citizens access to important environmental technologies at lower cost, which in turn will facilitate their use and benefit the environment. In addition, it will contribute significantly to APEC's core mission to promote free and open trade and investment, as embodied in the Bogor Goals.

The APEC seeks to maximise the energy sector's contribution to the region's economic and social well being, while mitigating the environmental effects of energy supply and use. The Asia–Pacific Economic Cooperation has an energy working group and two task forces to facilitate cooperation and promote regional energy trade and investment liberalisation, and in particular to consider climate change policies and approaches to reducing greenhouse gas emissions, including carbon pricing across the region. Asia–Pacific Economic Cooperation has also established an Asia–Pacific network for energy technology (APNet) to strengthen collaboration on energy research in the region, particularly in the areas of clean fossil energy and renewable energy sources.

Asian Development Bank (ADB)

The ADB is committed to helping developing member countries evolve into thriving, modern economies that are well integrated with each other and the world. The main devices for assistance are loans, grants, policy dialogue, technical assistance and equity investments. The bank projects that energy demand will be almost double in the Asia and Pacific region by 2030. There is an urgent need for innovative ways to generate power, while at the same time reducing greenhouse gas emissions. Compounding the problem is widespread energy poverty across Asia with almost a billion people still without access to electricity.

Since the early 1990s, ADB has supported various regional and subregional cooperation programs, including the Greater Mekong Subregion (GMS) economic cooperation program, the South Asia subregional economic cooperation (SASEC) program, the Central Asia regional economic cooperation (CAREC) program, the subregional economic cooperation in South and Central Asia (SECSCA) program, and the Pacific Plan.

Asian Development Outlook (ADO) 2013, prepared by the ADB, features a special chapter on Asia's energy challenges. The ADO stated that the region needs an ample supply of clean, affordable energy to continue its rapid growth in the coming decades. To achieve energy security, developing Asia must actively contain its escalating demand, aggressively explore new supply sources and technology, and progressively integrate regional energy markets and infrastructure. Among key messages, the ADB concludes that Asia must aspire to the degree of regional cooperation and integration in energy that currently prevails in Europe, by 2030.

United Nations Economic and Social Commission for Asia and the Pacific (ESCAP)

The ESCAP is the regional development arm of the United Nations for the Asia–Pacific region. The ESCAP has 62 member States. Among other countries of the NEA, Japan, Republic of Korea, China, Mongolia and Russian Federation are all members of the ESCAP.

On 27–30 May 2013, ESCAP countries at the Asian and Pacific Energy Forum in Vladivostok adopted a ministerial declaration and plan of action on regional cooperation for enhanced energy security and the sustainable use of energy in Asia and the Pacific, 2014–2018[22]. The plan of action, among other priorities, advocates the development and use of new and renewable sources of energy and the need to develop common infrastructure and harmonised energy policies with a view to increasing regional economic integration. The plan also envisages promoting initiatives for regional energy connectivity, including those focused on cross-border energy infrastructure development, such as oil and gas pipelines and electricity grids, through the identification of possible options for an integrated regional power network, which could contribute to the development of an Asian "energy highway".

Within the plan of action in relation to East and NEA, it was agreed to work towards:

1. Strengthening cooperation through networking among energy experts to facilitate exchange of information and views on national, subregional, regional and global issues related to energy security, and seek intellectual support in this regard.
2. Recognising that the subregion includes the largest energy producers and consumers; member States agree to cooperate to explore the full potential on intra-subregional energy trade.
3. Promoting initiatives for subregional energy connectivity, including those focused on cross-border infrastructure development, and considering possible ways to develop an intra-subregional power network and supply system to strengthen subregional cooperation and interdependence.

Energy resource imbalances along with accessibility and affordability issues are prompting a need for governments and development agencies within the Asia and Pacific region to increasingly look beyond national borders as a means to secure necessary energy supplies. In order to promote further regional cooperation, the ESCAP is recognising an opportunity to build upon existing initiatives towards enhanced integration of energy services within the Asia–Pacific region, by promoting the Asian energy highway (AEH) concept. The AEH aims to improve regional energy security by designing the platform to advance energy planning and infrastructure development across the Asia–Pacific region to regional level. In light of the necessary growth in the power generation sector in meeting rising demands, this platform could facilitate the development of an integrated regional energy grid as the focal point for promotion of diversification within the power generation mix, optimisation of efficiencies in energy resource consumption, and an ultimate enhancement of energy security for the region in a cleaner and lower carbon way.[23]

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[22] *For more information see http://www.unescap.org/apef/official-documents.asp*

[23] *Background paper prepared for the Expert Group Meeting on Conceptualizing the Asian Energy Highway, Urumqi, China, September 3–5, 2013.*

International Renewable Energy Agency (IRENA)

The IRENA seeks to make an impact on the world of renewable energy: By maintaining a clear and independent position, providing a range of reliable and well-understood services that complement those already offered by the renewable energy community and that gather existing, but scattered, activities around a central hub.

The international renewable energy community is large, resourceful, and rapidly evolving. The IRENA does not duplicate what others are doing, but seeks out, establishes and develops new synergies, facilitates dialogue, information and best practice sharing. Cooperation at the global, regional and national levels, knowledge sharing, enabling policies and enhanced capacity, as well as the encouragement of cash flows and strengthened technology and innovation, are essential elements in the agency's efforts. Also, IRENA is positioning itself as a platform for all-inclusive cooperation where stakeholders can make a positive contribution to the common goals. These partnerships and cooperation are essential underpinnings of IRENA's work.

The IRENA is uniquely positioned to bring together these different constituencies. It aims to become the convening instrument that binds all parts together and to become a powerful force in advancing the agenda of the widespread adoption and use of renewable energy, with the ultimate goal of safeguarding a sustainable future.

Furthermore IRENA's engagement with regional organisations seeks a balanced distribution in terms of geographical distribution and type of institution, including energy-specific organisations, relevant and active economic cooperation organisations and regional development banks. Activities in this component aim at expanding engagement with regional organisations in substantive areas by focusing on key regional priorities for renewable energies.[24]

The Economic Research Institute for the association of Southeast Asian nations (ASEAN) and East Asia (ERIA) has conducted studies on regional energy market integration over the past years and provided high impact policy advice to the ASEAN Energy Ministerial Meetings, including on energy cooperation and grid interconnections in the ASEAN Region. In 2013, IRENA collaborated with ERIA in improving the understanding of how renewable energy sources could best be integrated into the context of the ongoing ASEAN Power Grid Expansion. In this context, a study will be undertaken with a focus on assessments of renewable energy resources in relation to centres of demand and the potential transmission corridors. Above mentioned studies and IRENA's activities provide an opportunity for cooperation with the countries of NEA in relation to development of renewable energy and transportation corridors.

Potential of the ECT as a legal framework in the energy sector

Introduction

The ECT provides a multilateral framework for energy cooperation. In a world of increasing interdependence between energy exporters and importers, it is widely recognised that multilateral rules can provide a more balanced and efficient framework for international cooperation than is offered by bilateral agreements alone or by non-legislative instruments. To date, the ECT has been signed or acceded to by 52 States, the European Union and the European Atomic Energy Community (the total number of members of the Energy Charter Conference is therefore 54).

24 *IRENA Program of Work 2013*

In the region of NEA, Japan, Mongolia and Russia are member countries, though the latter officially advised on August 20, 2009 that it did not intend to become a contracting party to the ECT and the Protocol on Energy Efficiency and Related Environmental Aspects (PEEREA). China and the Republic of Korea are observer States to the EC.

A distinctive feature of the ECT is that it provides a set of rules that covers the entire energy chain, including not only investments in production and generation but also the terms under which energy can be traded and transported across various national jurisdictions to international markets.

The ECT provisions focus on five broad areas: The protection and promotion of foreign energy investments, based on the extension of national treatment, or most-favoured nation treatment (whichever is more favourable); free trade in energy materials, products and energy-related equipment, based on GATT/WTO rules; freedom of energy transit through pipelines and grids; reducing the negative environmental impact of the energy cycle through improving energy efficiency; and mechanisms for the resolution of State-to-State or investor-to-State disputes.

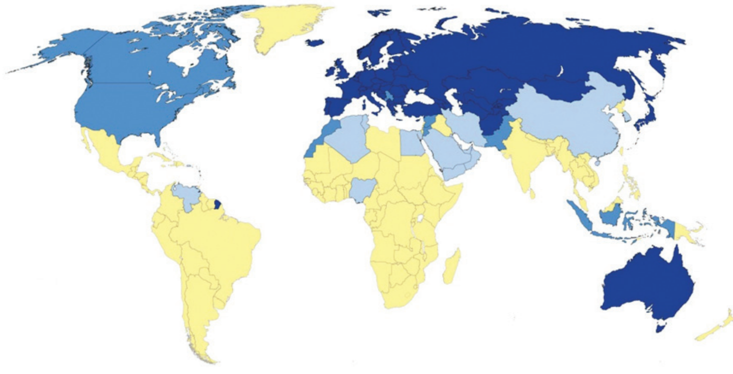
Potential of the ECT as a legal framework

A stable and increasing cooperation in the field of energy in NEA is facilitated by regional and international organisations including the EC as described above. However, the full potential for multilateral cooperation has not been fully realised. Energy security has been one of the most important issues facing countries in the region and this trend will be increasing in the years to come. The views of the growing demand for energy and environmental challenges are becoming an indispensable part of a broadly defined energy security as well. A significant opportunity exists for the countries to actively promote electricity generation from renewable energy sources (RES) which could lead to a new paradigm of economic development and well being of the people. The potential of the ECT as a legal framework for Gobitec and ASG is evaluated below with regard to the ECT geographical scope and core legal disciplines related to investment protection, transit regime and technology transfer.

The ECT brings together 54 members and 25 observers. The map[25] below shows that in the NEA, Russian Federation, Japan and Mongolia are signatories to the ECT. The Republic of Korea and the People's Republic of China are observers to the EC Conference. The EC could provide a policy platform between its signatories and observer States to discuss political and legal aspects related to the implementation of the Gobitec and ASG initiative for renewable energies in NEA.

[25] *This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.*

Figure 3-1: ECT membership map. Source: Energy Charter Secretariat



Note: Dark blue designates signatories to the 1994 ECT, and members of the EC Conference, blue designates signatories to the 1991 EC, and observers to the EC Conference, light blue designates observers to the EC Conference by invitation of the Conference (without signing the 1991 Charter)

The ECT is agreed on the principle of inclusiveness. It establishes a legal framework for long-term energy cooperation based on mutual benefits for energy producing, consuming as well as transit countries. The ECT is the only example of a comprehensive energy agreement with such broad membership; furthermore, it is open for accession by interested countries.

The EC modernisation process has been launched by the EC Conference to ensure that the potential of the Treaty's legal framework for long-term cooperation in the energy field is fully utilised. Modernisation is aimed at making the ECT more attractive for those major actors in the global energy market who have not yet become members. Those countries include major consuming countries, as well as major producing ones.

It is important to note that in accordance with the Modernisation of the Energy Charter Process, the EC Conference adopted a policy paper on CONEXO in 2012. The key objectives of the CONEXO policy are as follows:

- consolidation of the ECT among its original signatories;
- attraction of key energy players, who already have observer status, to eventually accede to the Treaty;
- promotion of the ECT and its operation on a broader geographical level.

In the context of the expansion policy, the EC countries are keen to promote accession to the ECT by the People's Republic of China and the Republic of Korea.

The ECT investment promotion and protection

Realisation of Gobitec and ASG initiates would require significant investments in RES of the Gobi Desert in Mongolia and China and construction of grid infrastructure in all countries in the region of NEA. International investors have limited experience of developing projects in China and especially in Mongolia. There are many areas of uncertainty regarding investments such as changing regulations, fiscal regimes, strategic and political factors. There is a need for stability in the long term which is crucial for any large-scale investment.

The development of legal instruments to protect and promote investment parallels the evolution of energy markets from national to international and global ones. The set of instruments of a "higher" (supranational) level does not usually supersede (or replace) the national legal instruments designed to protect investment but complements them, providing States and investors with broader, more reliable and, consequently, more competitive opportunities for implementing energy projects.

The reduction of investment risk and the creation of a stable and transparent investment climate is one of the major challenges. The ECT assists in this respect by offering binding protection for energy investors against key non-commercial risks, such as discriminatory treatment, direct or indirect expropriation, or breach of individual investment contracts. Once an energy investment is made, the ECT is designed so as to provide a stable interface between the investment and the host government. This stability is particularly important in the energy sector, where investments are highly strategic and capital intensive, and where risks have to be assessed in the long term.

The ECT is the only international agreement that explicitly proclaims State sovereignty over countries' energy resources. The Treaty's contracting parties recognise State sovereignty and sovereign rights over energy resources. Contracting parties are free to choose the governing system of property ownership for energy resources and systems. Furthermore, each State can freely decide the geographical areas to be made available for development of RES and grid infrastructure. The ECT contracting parties may specify and enjoy any taxes, royalties or other payments for such exploration and exploitation. Resource-owning States also have the right to regulate the environmental and safety aspects of such exploration and development.

Transit regime

The RES of the Gobi Desert cannot be developed at full scale without access to the regional electricity market of the NEA. Cross-border infrastructure and transit options become crucial to investment decisions. Predictable and reliable transit arrangements are of paramount importance for both long-term and short-term energy security and access to markets.

The relationship between an electricity exporting country and a transit country is one of mutual interest. While the exporting country wants to receive revenues from its exports, the transit country is interested in receiving transit revenues in cash or in kind. Both parties therefore have strong economic incentives to keep electricity flowing. In addition to its revenues from transit, the transit country in many cases gets the potential to access energy.

What is required is a regional system of rational energy use and energy security. This would avoid the current very large loss of economic efficiency that arises from duplicated and unnecessary investments in new generation and transmission capacity.

Energy transit, by its nature, is a multilateral activity, which cannot be regulated adequately through bilateral channels alone; the ECT is the most developed multilateral mechanism in existence through which governments can cooperate in this area. In terms of establishing rules for energy transit, the challenge for governments and the energy industry in the region of NEA is to find solutions that are compatible with institutional and regulatory regimes and structures in all countries concerned. A reliable transit regime in a large geographical area is therefore a question of finding common denominators.

The most common form of electricity transit involves the seller or the buyer arranging for transit capacity across the network(s) of a third country and paying a transit fee for the use of the third country' network. There are some cases, however, where buyer or seller has an ownership interest in the third country's high voltage transmission network.

Transit contributes to security of supply for consuming countries, market access for producer countries and income for transit countries. Thus, it contributes to free and open trade. Transit also represents risks, primarily of a political nature. Because the Gobi Desert is a very isolated geographical region, transit is a paramount consideration in developing RES and for the transport of electricity to the centres of demand.

The ECT addresses the important strategic issue of energy transit through its common legal obligations. Treaty provisions oblige participating States to take the necessary measures to facilitate transit of energy, consistent with the principle of freedom of transit, and to secure established energy flows. Transit countries are also under an obligation not to interrupt or reduce existing transit flows, even if they have disputes with another country concerning this transit. Through its investment and transit provisions, the Treaty also supports the establishment of new generation and transportation capacity.

Transfer of technology

Realisation of Gobitec RES potential requires a massive transfer of technology in order to avoid costly solutions and advancements in technological advances. Mongolia and China are in different categories in terms of RES technology development. Mongolia and China are the main countries that shall strongly benefit from technology transfer and development of local manufacturing industries.

Within Gobitec there are three main channels of technology transfer:

- sale of equipment and patented know-how;
- turn-key projects;
- transfer with large oil and gas exploration projects.

Protection of IPR plays an important role for the transfer of replicable technology in small-scale projects; for example, those related to solar panels and wind turbines. Improving technology to protect the environment raises the issue of incentives for the transfer of state of the art technology. International and State regulations are usually necessary.

The ECT countries agreed to promote access to and transfer of technology (TOT) on a commercial and non-discriminatory basis to assist effective trade in equipment with full respect to the protection of IPR. The Treaty provides legal grounds for the contracting parties to work towards the elimination of existing barriers and for the creation of no new obstacles to the TOT. Moreover, the contracting parties shall encourage favourable conditions for the transfer and dissemination of energy efficient and environmentally sound technologies that are in keeping with the adequate and effective protection of IPR.

It is important that the ECT has comprehensive provisions on investment protection and promotion because the FDI is the primary investment vehicle for longer term, private-sector technology transfer. While FDI flows involve financial inputs, they also involve the capitalisation of technology, knowledge, skills, and other resources that represent a stock of assets for production. While FDI does not necessarily result in TOT, relatively little TOT takes place outside the foreign investment context.

Common legal and regulatory framework

Another critical success factor in creating a regional power pool is the extent to which governments and the operators of their respective national power grids are able to define a common legal and regulatory framework to facilitate achievement of regional objectives.

A prospective cross-border project for the transportation of electricity raises a multitude of complex political, commercial, fiscal, environmental, technical and legal issues. The complexity of these issues frequently poses an unnecessary barrier to the realisation of a much-needed energy project. For example, there is the issue of individual States with different political and economic interests, each with their own separate jurisdiction. There is also the issue of various entities, both public and private, taking part in the project.

Furthermore, cross-border projects are normally financed by both private and public financial institutions which require certain guarantees regarding the economic feasibility and the ultimate legal security of the prospective project. The EC Secretariat developed market and system interoperability agreement guidelines for cross-border electricity projects and a set of model agreements with a view to providing parties interested in energy-related projects with a neutral and non-prescriptive starting point for negotiations. Electricity model agreements consist of:

- Intergovernmental electricity model agreement (IG-EMA) for State-to-State agreements; and
- Host government electricity model agreement (HG-EMA) for agreements between an individual State and the project investors.

Comprehensive legal guidelines and model agreements could facilitate and guide prospective negotiations for the construction and operation of cross-border energy projects in NEA and could therefore be of significant operational value.[26]

Conclusions

Further progress on Gobitec and ASG in the region of NEA requires the development of an effective regional governance strategy (roadmap) in order to promote intergovernmental energy cooperation. Different cooperation forums for ensuring greater harmonisation among regional electricity industry players at political, institutional, and technical levels are required in order to make further progress towards the establishment of a regional market. Some countries in NEA are engaged through a political dialogue at ESCAP and through the ECNEA. The ECT provides a legal platform to discuss and enhance the regional cooperation.

The countries in the region shall jointly work on the elimination of all possible physical, trade and regulatory barriers to ensure effective electricity trading in NEA. It is necessary to put in place new regulatory mechanisms aimed at ensuring, among other things, access to networks.

Investment in the Gobitec and ASG project is capital intensive, making it one of the major challenges for potential project developers. The countries in NEA have different legal and regulatory regimes and different industry structures which may hamper investment in the development of RES and electricity transmission infrastructure.

[26] *These documents could downloaded free of charge at http://www.encharter.org*

An improved investment climate and a more harmonised set of trade and transit rules, developed on the principles of the EC and focusing on specific conditions of the region, are likely to facilitate long-term investor confidence by reducing risk and uncertainty. The ECT contains legally binding rules on foreign investments for its member countries that are applicable to all types of energy, including electricity from RES. All countries that participate in the ECT should create stable, favourable, non-discriminatory and transparent conditions for foreign as well as national investment. The ECT has strong potential to promote investment and regional energy trade in the region of NEA.

Regarding challenges, it shall be noted that the ASG's long-distance pipelines and high voltage electricity lines that could be built across several territories imply interdependence and potential risks. Strong and stable relations between countries in NEA as well as regional stability are necessary to ensure reliable and safe transportation of electricity from production to consuming centres. The countries in the region have little specific national legislation and regulation in dealing with cross-border regulations. With increasing energy market liberalisation, there is a greater need for internationally accepted trade and transit rules.

Another critical success factor in creating a regional power pool is the extent to which governments and the operators of their respective national power grids are able to define a common legal and regulatory framework to facilitate the achievement of regional objectives.

Weak protection of IPR in China and Mongolia could be another significant barrier to technology transfers in the implementation of the Gobitec and ASG initiatives. In this context the ECT offers a solid legal base to address the issues related to TOT based on internationally recognised standards.

The region urgently needs further consultations to address certain issues, such as promotion of investment, technology transfer, transit capacities, the building and allocation of transmission lines, which shall be environmentally responsible, safe and reliable. A proactive approach should be taken by all governments concerned. The existing legal framework of the ECT and a policy platform of the ECNEA in NEA could be grounds for such consultations.

The EC process in NEA shall be further strongly promoted by Mongolia to intensify regional cooperation and promote accession to the ECT by other countries in the region. In the short term the EC Conference shall continue cooperation with the countries in the region of NEA in order to facilitate policy discussions related to the ECT's core competences, namely, investment promotion, trade and transit of energy materials, technology transfer, access to capital, energy efficiency and environmental issues.

With today's focus on climate change and energy security, it is essential to fully use the ECT potential to the advantage of participating member and observer States of NEA.

THE BENEFITS OF REGIONAL INTEGRATION

Power supply and demand in Northeast Asia

According to the ADB (2013), Asia contributed 28% to global GDP in 2010 and it will represent over 50% of global GDP by 2050. Such economic expansion requires huge amounts of energy. While Asia accounted for 34% of world energy consumption in 2010, this figure will increase to 51% by 2035.

Similarly, electricity demand in NEA will increase to 1.7 times from 2010 to 2030, mostly owing to the rapid growth in China. During this period, fossil fuels are assumed to remain dominant resources for feeding electricity demand in the region. According to the forecast of IEA's New Policies Scenario, in China, cumulative gross capacity additions from 2012 to 2035 are 428 GW for coal, 165 GW for gas, 387 GW for wind and 122 GW for PV. In terms of generation, China continues to contribute the largest increase in coal-fired generation, accounting for two-thirds of the global increase over that period (IEA World Energy Outlook, 2012). However, reducing the dependence on fossil fuels for power production is crucial in order to avoid the catastrophic consequences of climate change.

Figure 4-1: Electricity demand of Northeast Asia by country (BAU scenario). Source: data submitted by the project partners

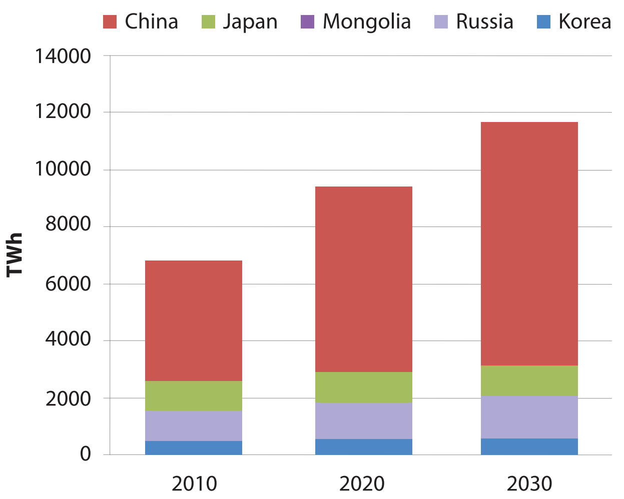
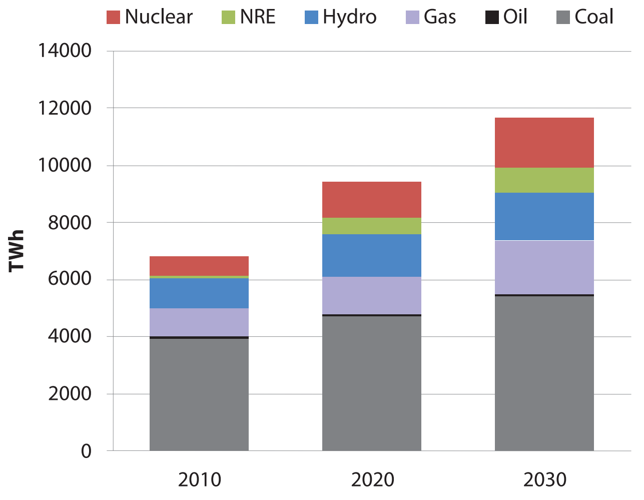


Figure 4-2: Electricity demand of Northeast Asia by fuel (BAU scenario). Source: data submitted by the project partners



In this sense, the Gobitec and ASG project has a large potential to decarbonise the power supply in the region. The 100 GW of renewable generation from the Gobi Desert will replace existing fossil fuel power plants and avoid new facilities that would be otherwise built. Moreover, the project will promote the increase of renewable energy developments in participating countries through grid integrations. There are considerable signs of change towards a renewable-based electricity supply. In China, production of renewable electricity increased more than that of non-renewable electricity between 2011 and 2012 (BP statistical review, 2013). In Mongolia, a low-cost potential of tapping several terrawatt (TW) of renewable power have been identified, whereas Japan may re-regulate its power market to enable the development of PV and wind power to reach a capacity of 10 GW per year. Russia and Korea have similar potentials. With such developments, a temporary, abundant low-cost renewable supply increases the value of the transmission capacity. Concurrently, larger transmission capacity increases the profitability of further investments in low-cost production capacities of renewables in resource-rich areas. This section analyses the expected benefits of the Gobitec and ASG project by considering various perspectives.

Overview of benefits of system integration

Figure 4-3 shows the various benefits that large-scale system integration can bring to all participating countries of this project, especially to Mongolia. Benefits are divided in this manner because this project focuses on renewable development in the Gobi Desert, which affects Mongolia most.

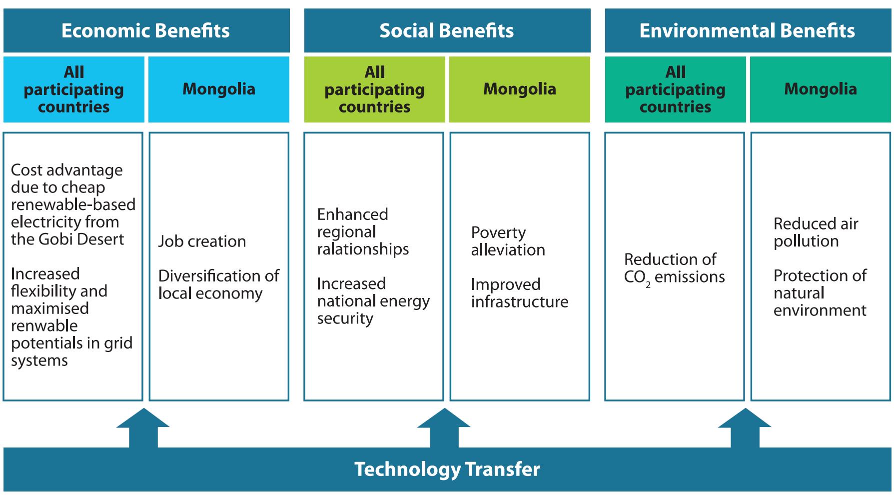
Benefits are divided into economic, social, and environmental improvements. Regarding economic benefits system integration can bring more power generation projects to Mongolia, contributing to more local jobs in the fields of construction, installation, and manufacturing. This also helps to diversify the local economy in Mongolia, which is heavily dependent on the mining industries. This integration also provides other participating countries with access to the cheapest electricity in the region. System integration also increases grid management flexibility, which then contributes to augmenting the potential of renewables by enabling the incorporation of more variable renewables, such as wind and PV power into the grid.

The social benefits of regional grid system integration can also enhance regional relationships between participating countries. Creating a market and institutional mechanism of an integrated grid system requires confidence-building between all participating countries based on long-term negotiations and commitments. This helps in augmenting a mutual understanding between the participating countries. By diversifying energy sources, system integration also benefits the participating countries in terms of increasing national energy security. For Mongolia, regional grid integration can alleviate poverty through job creation and through an increase of electrification, which is known to enhance various social and welfare benefits. Technologies provided by developed countries will also improve infrastructure.

Furthermore, there are environmental benefits. Regional grid integration can encourage more renewable electricity generation in the region – an incorporation that can contribute to reducing CO_2 emissions. In Mongolia, an increase in renewable energy generation reduces the number of coal power plants and related-air pollution, which can also contribute to the protection of the natural environment.

If all benefits are to materialise, technology transfer between the countries, particularly from developed countries to developing countries, is crucial. These benefits are further explained in the following sections.

Figure 4-3: Benefits of regional grid integration



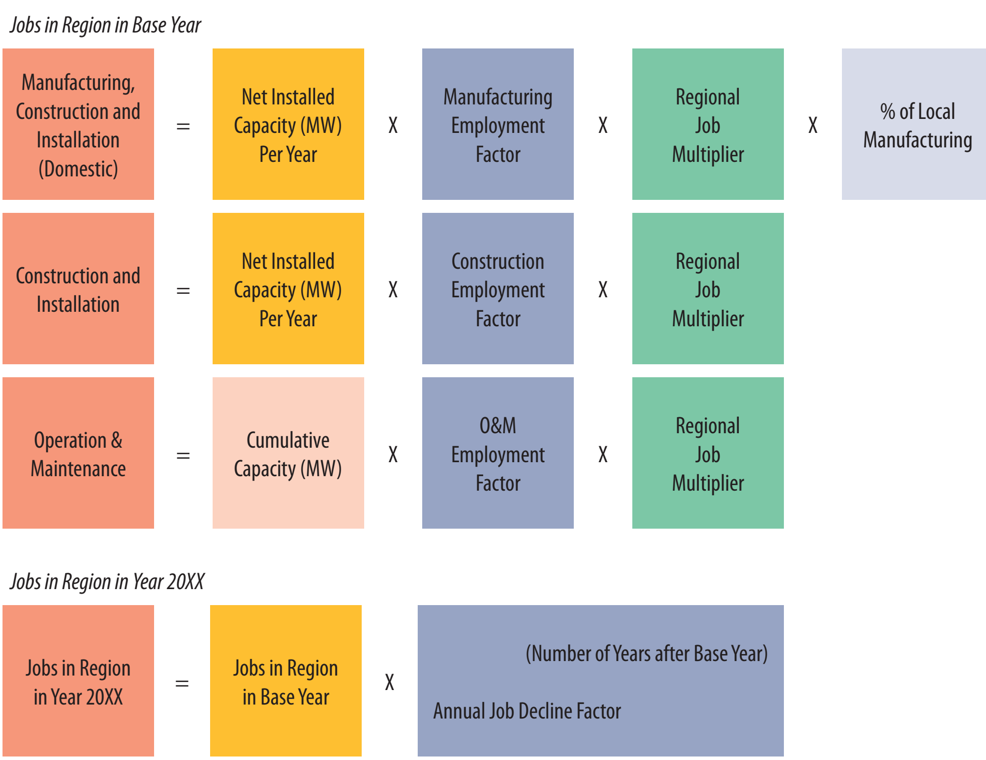
Economic benefit for Mongolia

For Mongolia, the largest economic benefit from the Gobitec and ASG project is job creation because of the implementation of various renewable energy projects connected to the grid system. In this section, the employment effect of the proposed project is assessed. The international energy agency's renewable energy technology deployment (IEA-RETD) categorises three main methods for calculating job creation: (1) the employment factor method; (2) the input–output (I–O) modelling method; (3) the full economic modelling method (Breitschopf et al., 2012). The third method requires extensive data and resources, which are unavailable; therefore, this method is not considered. The first method is the simplest; however, it cannot calculate indirect economy-side employment effects (i.e. employment in upstream industries) because only the respective direct renewable industries are considered. The I–O modelling method can estimate indirect economy-wide employment effects. However, because of the unavailability of a recent I–O table for Mongolia, the employment factor method is used to calculate the energy sector jobs created for different types of renewables. Although the employment factor method is not designed to capture indirect job links, it uses more recent data than the I–O method can use.

Employment factor approach to calculate job creation effect

The employment factor method quantifies the number of jobs directly involved in manufacturing, construction and installation of projects, as well as the O&M of renewables. The method requires the following: (1) physical data on installed capacity or electricity output using renewables; (2) technology-specific employment factors relating the number of jobs to the physical data (e.g. labour input per installed capacity or generated electricity). Here, the employment effects of using wind and PV are considered. Technology-specific employment factors are taken from existing literature and research. However, because these factors are usually available in OECD economies, differences in regional labour productivity ratios are considered by establishing a regional multiplier for Mongolia. In addition, employment factors may change as technology learning widens in the future. To consider such effects, the annual decline ratios in relation to job factors are set. These factors and the I–O ratio also change as domestic production increases in the future; I–O ratios are assumed to take such changes into account (Rutovitz and Atherton, 2009; Rutovitz and Usher, 2010; Breitschopf et al, 2012).

Figure 4-4: Method of calculation of employment effects



Photovoltaic

For the PV industry, the employment factors gathered by Wei et al. (2010) vary from 7.14 to 30.00 for construction and installation and from 0.12 to 1.00 for O&M. The factors expressed in EPIA (2008) for the manufacturing, construction/ installation phases, and BMU (German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2008) for the O&M phase are used. For manufacturing and construction factors, the base year is set as 2012; for O&M, the base year is set as 2010.

Table 4-1: Employment Factors of PV Technology, Sources: EPIA (2012) and BMU (2008)

Activities	Employment Factor		Basis
	Jobs/ Annual MW	Jobs/ Cumulative MW	
Direct Employment			
PV Module Manufacturing	5.00		Annual
Construction/Installation	7.00		Annual
Other Direct Employment*	3.00		Annual
O&M		0.40	Cumulative
Subtotal	15.00	0.40	
Indirect Employment**			
Subtotal	30.00		
Total	45.00*	0.40	

* Other direct employment includes jobs created by companies or individuals fully dedicated to the PV value chain, such as inverter manufacturing and PV project administration and engineering, and sales.

** Indirect employment is created by more generic components or services such as raw materials supply and production equipment, etc., which are necessary for PV manufacturing and project execution but the providers are not fully dedicated to the PV value chain.

Wind

Several studies and data are available for the wind energy industry. Wei et al. (2010) summarised the employment factors found in four studies, which ranged from 2.57 to 10.96 for the construction phase and from 0.14 to 0.40 for O&M, indicating that the employment factors vary depending on factors such as time, country and survey methods. For this study, the most recent data listed in the European Wind Energy Association (2009) is used. Table 4-2 shows the employment factors for wind energy technology, with the base year set to 2008.

Table 4-2: Employment Factors of Wind Energy Technology, Source: EWEA 2009

Activities	Employment Factor		Basis
	Jobs/ Annual MW	Jobs/ Cumulative MW	
Direct Employment			
WT Manufacturing: Direct	7.5		Annual
Construction/Installation	1.2		Annual
Other Direct Employment*	1.3	0.07	75% Annual / 25% Cumulative
O&M		0.33	Cumulative
Subtotal	10.0	0.33	
Indirect Employment			
WT Manufacturing: Indirect	5.0		Annual
Subtotal	5.0		
Total			

*independent power producers (IPP)/utilities, consultants, research institutions, universities, financial services and others

Regional job multiplier

Because these numbers were derived from developed countries and regions (i.e. mostly Europe), a regional multiplier factor is used to adjust the factor fit to the state of development in Mongolia and developing Asia. Because the labour productivity of developing regions differs greatly from (and are typically lower than) those in developed regions, the regional job multiplier is used to capture the differences between them. Rutovitz and Atherton (2009) and Rutovitz and Usher (2010) use average GDP per worker for industries excluding agriculture as a proxy of labour productivity. For forecasting, growth rate in GDP per capita is used as a proxy of growth rate in labour productivity. Table 4–3 shows that the regional job multiplier for Mongolia in the base year 2009 is 2.78 (= 1/0.36).

Table 4-3: Labour productivity OECD and Developing Asia in base year 2009. Source: ILO (2009)*

	Whole Economy GDP Per Worker (1990 USD at PPP)	Whole Economy Excluding Agriculture GDP Per Worker (1990 USD at PPP)	Ratio to OECD**	Regional Job Multiplier***
OECD	47,173	48,990	1.0	1.0
Developing Asia	10,776	17,564	0.36	2.8

* Labour productivity is defined as average GDP per worker.

** Ratio to OECD = (GDP per worker of whole OECD economy excluding agriculture)/(GDP per worker of the whole economy of the respective region excluding agriculture)

*** Regional Job Multiplier = 1/Ratio of Developing Asia to OECD

Compound average annual growth rates in GDP per capita for the OECD region from the World Energy Outlook 2012 (IEA, 2012) are 2.2% for 1990–2010 and 2.1% for 2010–2030, and the rates for non-OECD Asia are 4.9% for 1990–2010 and 5.5% for 2010–2030.

Table 4-4: GDP Annual growth rates. Source: IEA (2012a)

	1990–2010	2010–2030
OECD	2.2%	2.1%
Developing Asia	4.9%	5.5%

Job decline factor

Regarding job decline rates, the rates calculated by Greenpeace International (2010) are used. Annual job decline rates for manufacturing and installation are as follows.

Table 4-5: Annual job decline rates. Source: Rutovitz and Usher (2010)

	2010–2020	2020–2030
Wind	3.1%	0.1%
PV	5.9%	5.3%

Employment factors in Mongolia

The employment factors for PV and wind in Mongolia, calculated from the above values, are shown in Table 4–6.

Table 4-6: Employment factors for PV and wind in Mongolia for 2015, 2020, 2025, and 2030

	Unit	2015	2020	2025	2030
PV					
Direct Employment					
PV Module Manufacturing	Jobs/Annual MW	9.61	6.02	3.89	2.52
Construction/Installation	Jobs/Annual MW	13.46	8.43	5.45	3.52
Other Direct Employment	Jobs/Annual MW	5.77	3.61	2.34	1.51
O&M	Jobs/Cumulative MW	0.68	0.43	0.27	0.17
Indirect Employment	Jobs/Annual MW	57.67	36.12	23.35	15.10
Wind					
Direct Employment					
WT Manufacturing: Direct	Jobs/Annual MW	13.88	10.07	8.50	7.18
Construction/Installation	Jobs/Annual MW	2.22	1.61	1.36	1.15
Other Direct Employment	Jobs/Annual MW	2.41	1.74	1.47	1.24
	Jobs/Cumulative MW	0.13	0.09	0.08	0.07
O&M	Jobs/Cumulative MW	0.61	0.44	0.37	0.32
Indirect Employment					
WT Manufacturing: Indirect	Jobs/Annual MW	9.25	6.71	5.67	4.79

Employment and income created by the Gobitec 100 GW PV and wind projects

Implementation schedule of 100 GW PV and wind projects in Mongolia

In this project, wind and PV projects totalling 100 GW are in planning in Mongolia between 2015 and 2030. Table 4–7 shows the implementation schedule and local manufacturing ratio.

Table 4-7: Implementation schedule

	Total (GW)	Wind (GW)	PV (GW)	% Manufactured and Executed in Mongolia
2015	1	0.5	0.5	0%
2016	1	0.5	0.5	0%
2017	1	0.5	0.5	30%
2018	1	0.5	0.5	30%
2019	1	0.5	0.5	30%
2020	5	2.5	2.5	50%
2021	5	2.5	2.5	50%
2022	5	2.5	2.5	50%
2023	5	2.5	2.5	50%
2024	5	2.5	2.5	50%
2025	10	5	5	50%
2026	10	5	5	70%
2027	10	5	5	70%
2028	10	5	5	70%
2029	15	7.5	7.5	70%
2030	15	7.5	7.5	70%
Total	100	50	50	

Direct employment effects and income generation in Mongolia

The employment factors shown in Table 4–6 indicate that the Gobitec and ASG PV and wind projects will create the following new jobs between 2015 and 2030 in Mongolia. Table 4–8 shows the approximately 880 thousand new jobs for the 100 GW projects, with more jobs in all manufacturing, construction and O&M for wind than for PV. Figures 4–5 and 4–6 show the annual job creation for wind and PV, indicating that the 100 GW projects will have important effects on the Mongolian economy through job creation for a 16-year duration.

Table 4-8: Direct employment of 100 GW PV and wind projects in Mongolia

	PV	Wind	TOTAL
Manufacturing	106,891	245,462	352,353
Construction/Installation	268,629	67,155	335,784
O&M	64,134	59,483	123,617
Others	62,313	112,462	174,775
TOTAL	395,077	484,562	879,639

Figure 4-5: Employment for 50 GW of PV projects in Mongolia

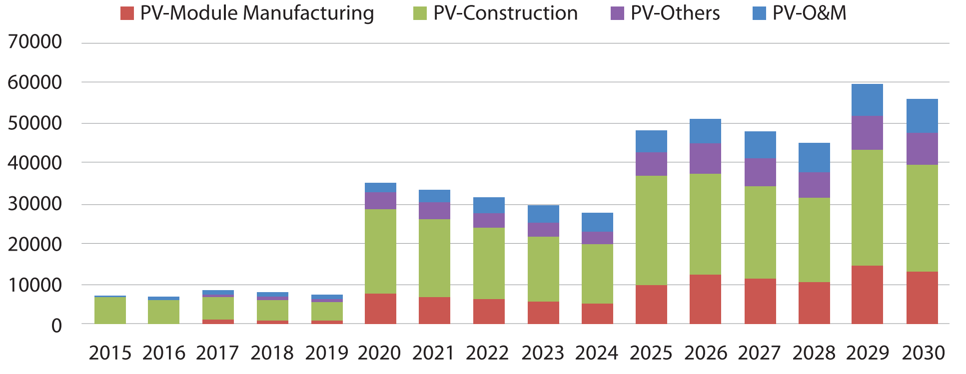


Figure 4-6: Employment for 50GW of wind projects in Mongolia

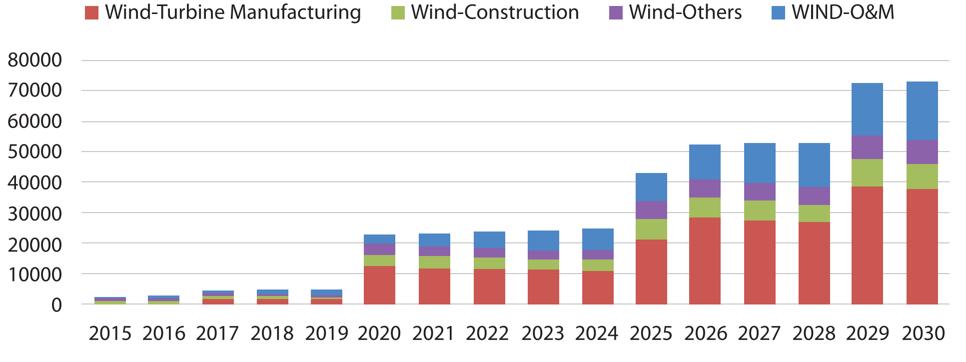


Table 4–9 shows the income generated by these employment effects over the 16-year period. More than 9 billion USD will be generated by both wind and PV projects.

Table 4-9: Income Generated by 100GW PV and wind projects in Mongolia (2013 USD PPP)

	Wind	PV	TOTAL
Manufacturing	2,714,599,133	1,148,432,891	3,863,032,024
Construction/Installation	711,479,339	2,737,265,319	3,448,744,658
O&M	1,250,640,029	670,226,247	1,920,866,276
Others	627,255,640	689,059,735	1,316,315,375
TOTAL	4,676,718,501	4,555,924,457	9,232,642,958

Employment effects outside Mongolia

The Gobitec 100 GW PV and wind projects have strong employment potentials outside Mongolia as well. Both direct and indirect employment created by the 50 GW PV projects in Mongolia will contribute to the total of 368,846 new jobs outside Mongolia over the 16-year period. Similarly, the 50 GW wind projects will create 191,098 new jobs outside Mongolia, indicating PV has stronger effects on job creation outside Mongolia.

Regional employment effects by the ASG project

Similarly, regional employment effects arising from the ASG project were estimated by the employment factor approach. The jobs and economic development impact (JEDI) model that is monitored by the NREL of the Unites States provides an employment factor for power transmission line projects (Lantz and Tegen, 2011, California's Clean Energy Future, 2012). According to this NREL modelling study, HV transmission line projects can create 29.44 job-years per mile. The ASG project will build a total of 7,530 km of transmission lines in the region, creating a total of 137,754 jobs over the years in the region.

Economic benefits for all participating countries

The Gobitec and ASG project will generate two major economic benefits for all participating countries. First, the region will benefit directly from the cost advantage of electricity production from the wind and solar power plants in the Gobi Desert over the existing electricity production in the participating countries. These countries can replace their expensive electricity, domestically generated using fossil fuels, with cheap electricity generated using abundant RES in the Gobi Desert. Moreover, the grid integration indirectly provides region-scale economic benefits. Electricity output from variable renewable energy such as PV and wind is variable in response to changing meteorological conditions. Variable renewable generation typically requires more grid system flexibility to maintain system balance. Although grid systems always require flexibility in order to accommodate fluctuations in loads and to manage supply interruptions – those systems with high penetration of variable renewable generation require additional flexibility to accommodate greater fluctuations in power generation. There are four important measures to increase flexibility of grid systems (IEA, 2011): Dispatchable power plants (e.g. gas turbines or hydroelectric plants), energy storage (e.g. pumped hydro and advanced energy storage), interconnection for trade with adjacent areas, and demand-side management and response. Interconnection especially plays a significant role with regard to flexibility. It allows shared use of flexible resources in order to manage the variability of renewable output among neighbouring countries. The ASG connects the grid systems of participating countries, and yields greater flexibility of their grid systems to accommodate more renewable energies in their own countries.

Economic benefits from cost advantage of electricity production

This project will bring direct economic benefits to the participating nations, because a large-scale renewable energy power generation system in the Gobi Desert can provide environmentally friendly and low-cost electricity. At the same time, the ASG project will connect power grid systems of the participating countries, providing them with access to a low-cost source of power.

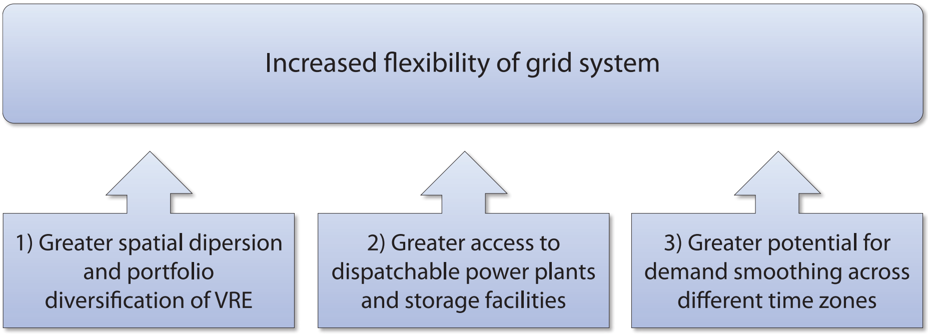
As shown in Chapter 2, the cost of providing electricity through PV or wind power generation systems from the Gobi Desert, including the cost of power transmission, is 0.133 USD/kWh, lower than the electricity charges of importing nations, which is 0.140 USD/kWh in the weighted average. This would directly benefit the participating nations. Based on the rough estimation of cost analysis, the total economic benefit for the participating nations is expected to reach 17billion USD per year.

Furthermore, the ASG project would not simply provide a one-way transmission of PV or wind power to the participating nations. The countries could share electricity with one another through the use of interconnected power grids. In other words, ASG would make it possible for the nations to send electricity from their existing power plants, in addition to receiving PV and wind power from the Gobi Desert. Unlike AC lines, direct current (DC) lines can be controlled at both ends, so the volume and flow of electricity can be managed according to the supply and demand situations. Power-plant investments and operations would be optimised when the countries' power grids are connected over a widespread area. Moreover, China, South Korea, and Japan, which are major importers under the Gobitec project, could also exchange their domestic electricity with one another when they have surplus supply.

Economic benefits of grid integration

Grid integration provides economic benefits. Variability is the characteristic disadvantage of variable renewable energy (VRE) and one of the main barriers to increased use of VRE in grid systems. Grid systems can absorb variations at a certain penetration level of VRE; however, high penetration of VRE (30% or more) requires additional flexibility for grid system uses. In that sense, grid integration can help participating countries increase their flexibility in grid system solutions. According to the IEA study (IEA 2011), the maximum extent of flexible capacity offered by an interconnection is approximately twice its rated capacity. If a transmission line is exporting at its maximum, an overall power ramp results over the system that is double its rated capacity. Three major factors can increase flexibility of grid systems: (1) greater spatial dispersion and portfolio diversification of VRE; (2) greater access to dispatchable power plants (e.g. gas turbines or hydroelectric plants) and storage facilities (e.g. pumped hydro and advanced energy storage) located in other countries or regions; and (3) greater potential for demand-smoothing across different time zones. As a result of the increased flexibility of grid systems, the participating countries can use the potential VRE in the Gobi Desert and maximise their own potential VRE at low cost.

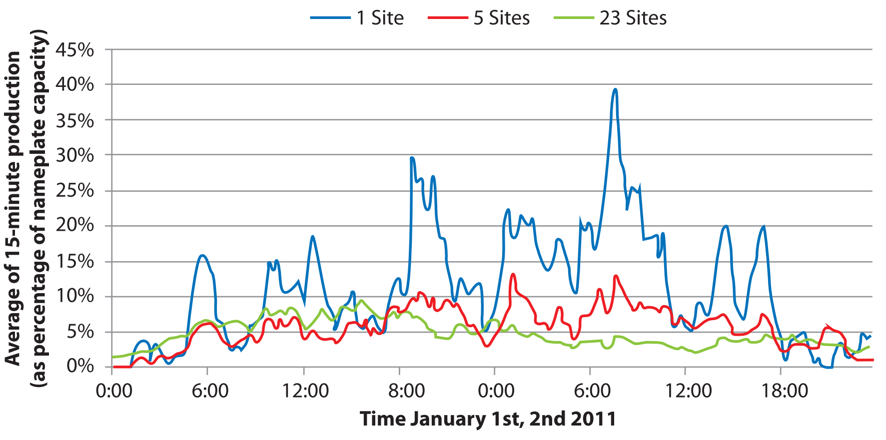
Figure 4-7: How grid integrations help increase flexibility in grid systems



1) Greater spatial dispersion and portfolio diversification of VER

Greater spatial dispersion and portfolio diversification of VRE power plants can increase their complementarities; the outputs from the VRE plants become smooth and can fluctuate at various times in different locations. In general, because meteorological conditions vary in each region, the accumulation of VRE outputs with grid integrations can help with assisting the supply of VRE into the grid systems (IEA, 2011).

Figure 4-8: The impact of smoothing for wind power over varying number of sites Source: Miller et al. (2013)



2) Greater access to dispatchable power plants and storage facilities

Grid systems must have sufficient dispatchable power plants and storage facilities to compensate for variable output from VRE in order for the supply of electricity to always correspond to the level of demand. Higher penetration of VRE in grid systems requires an increasing number of facilities for dispatch and storage. The cost of reserving or installing those facilities is considerably high for grid operators. Grid integration provides a pool of such facilities and allows participating countries to access those facilities owned by other countries. Efficient use of existing facilities results in saving grid system costs by avoiding additional investments for backup facilities. European countries already apply such "pooling" of dispatchable power plants and storage facilities into their grid managements through interconnections and cross-border trades.

The following graphs show annual load curves for South Korea and Japan in 2012. (For Japan, the graph is for the service area of Tokyo Electric Power Co.) In South Korea, there were only 83 days (23%) when the country's power use exceeded 90% of its maximum demand of that year (68,391 MW). In Japan (within the service area of Tokyo Electric Power), the use of electricity exceeded 90% of the country's maximum demand for that year (45,700 MW) only for 300 hours (3%). These graphs demonstrate that the two countries have enough reserve capacities to meet their maximum demand, which occurs only during a limited period of time. When the countries' power systems are connected through ASG, they will be able to provide excess power to each other, allowing them to utilise their reserve capacities more efficiently and reduce expenses.

Figure 4-9: Korea's Load Curve in 2012. Source: KPX

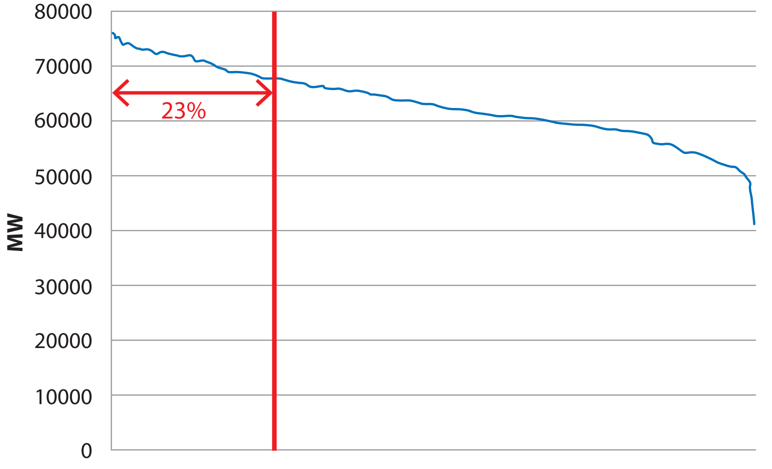
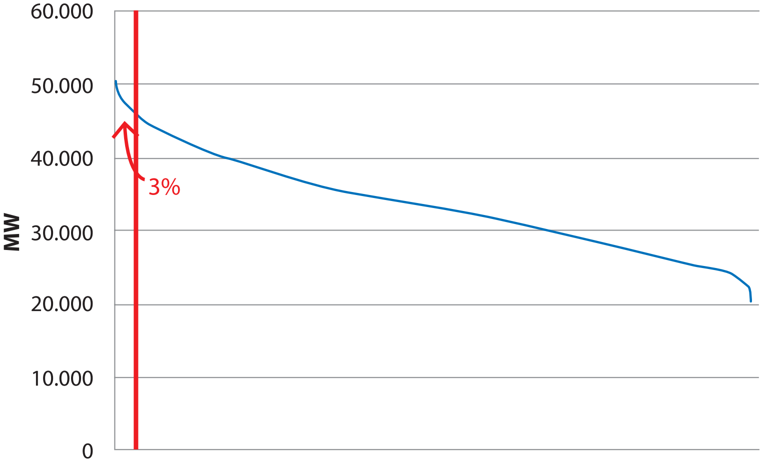


Figure 4-10: Japan's (TEPCO area) Load Curve in 2012. Source: TEPCO



3) Greater potential for demand-smoothing across time zones

Because peak demand is likely to vary across time zones, grid integrations and cross-border trade in the region may smooth electricity demand. For instance, Table 4–10 shows the time differences of peak-load between Korea and Japan. Moreover, seasonal differences in the load curves among participating countries may provide another reason that system integration would enhance operational efficiencies of the countries' grid systems. In South Korea, demand peaks in the winter; in Japan, demand occurs in the summer.

Table 4-10: Comparison of peak-load time in Korea and Japan (TEPCO) Sources: KPX and TEPCO

	Korea's Peak-load time	TEPCO's Peak-load time
2012/8/30	11:00	14:00
2012/12/26	11:00	17:00

In addition to the demand-smoothing effect, ASG would allow participating countries to use the system as reserve capacity when supply runs short. In Mongolia, the coal-fired No. 4 thermal plant in Ulaanbaatar provides 20% of the electricity used in the country in the winter. If this plant were to stop operations, the country could face an extremely serious supply situation. Because all the power plants connected to the central grid provide coal-fired facilities, it is difficult to add to their output capacity. Thus, the country implements rolling blackouts and procures power from Russia when demand surges. When the broad alliance is formed, Mongolia will be able to receive electricity from other nations.

Likewise, electricity consumption has surged in South Korea in recent years. (The country's power use increased by 1.8 times during a 10-year period from 2001 to 2011.) The country's supply situation has become tighter as the construction of power plants cannot keep up with rising electricity demand. With the reserve capacity falling to 5.5%, the government strengthened its efforts to enforce energy saving measures, such as the rolling blackouts of 2011. However, there is still a possibility that South Korea may experience supply shortages in the future.

Environmental benefits of system integration

One of the major benefits of the Gobitec/ASG project would be environmental benefits. The project would provide 100 GW of electricity generated by PV and wind in the Gobi Desert to the participating nations. That would allow the countries to reduce emissions of carbon dioxide, sulfur oxide, nitrogen oxide, dust, and other pollutants from their existing thermal power plants or new facilities that they would otherwise build.

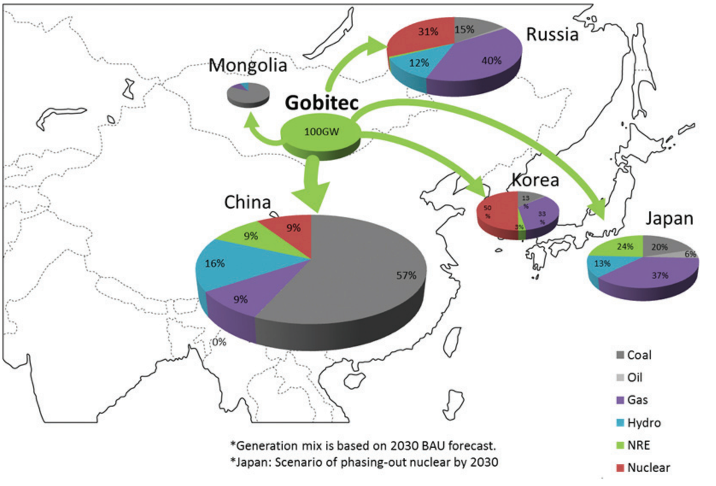
In this section, the CO_2 emission reduction effect of the project is estimated. The same amount of electricity is presumably generated by existing power plants (mainly thermal power plants) is replaced by the importation of renewable electricity from the Gobi Desert to each country. The CO_2 emission factors of respective countries and expected emission reductions are shown in Table 4–11. Because it is assumed that 85% of electricity generated from the project goes to China, the reduction in emissions in China accounts for a large share. The total for the region is 187 Gt CO_2 per year.

Table 4-11: CO_2 emission reduction. Sources: IEA (2012b)

	Unit	Korea	China	Japan	Mongolia	Total
CO_2 emissions per kWh from electricity generation (2010)	tCO_2/MWh	0.533	0.766	0.510*	1.492	-
Emission Reduction	GtCO2	21	149	13	4	187

* Emission factor of 2011, Source: The Federation of Electric Power Companies of Japan

Figure 4-11: Generation mix of 2030 and RE imports from Gobitec



Social benefits of system integration

Regional grid integration brings new and/or upgraded electricity infrastructure to Mongolia. Thus, international infrastructure must meet international technical standards, and the quality of power generation, transmission, and distribution infrastructure will certainly be upgraded. In addition, the grid system is accompanied by a diverse set of auxiliary technologies that help manage the physical grid and the electricity market system. Regional grid integration and related power generation projects may also bring updated auxiliary technophiles to Mongolia.

With an extended grid, more people benefit from electrification. Electrification, in particular in rural areas, provides diverse social and welfare benefits. A study conducted by the World Bank (2008) indicated that most households connect to the grid within the first 3 years that the grid becomes available. The same report summarises the following benefits of rural electrification.

- Electricity reduces the cost of energy for the user.
- Rural electrification reduces the cost of operating lighting and TVs, which are the most common uses of electricity.
- Indoor air quality and health improvement, as well as improved health knowledge through increased television usage, are linked to rural electrification and the effects are quantifiable and significant.

- Electrification benefits clinics at community level. It also helps improve the quality of schools and attracts and retains skilled staff in schools and health centres.
- Most connections in rural areas are residential. A greater number of home businesses prosper in electrified communities than in those without electrification.
- World Bank (2008).

Mongolia is one of the fastest-growing economies in the world. Its GDP average growth rate (between 2004 and 2008) was 9.0%; it reached 17.3% in 2011, a dramatic increase from 6.4% in 2010 (World Bank, 2013). Currently, Mongolia is classified as a low-middle income country by the World Bank. This strong economic growth was reflected in the rapidly decreasing poverty level. The poverty level estimated by the World Bank and the National Statistical Office of Mongolia was 29.8% in 2011, 9.4% less than 2010 (World Bank, 2012). However, this was much higher than the poverty rate of East Asia and the Pacific Region in 2010, which was 12.48% (World Bank, 2013). In addition, the poverty ratio in rural areas in Mongolia is 33.3%, which is 6.7 points higher than in urban areas, indicating that the Gobitec and ASG project can provide rural areas with the significant rewards of electrification.

Note) Regional Aggregation was compiled using 2005 PPP and a $1.25/day poverty line.

In terms of off-grid electrification, the government of Mongolia has, since 2000, teamed up with the World Bank to provide cheap and clean electricity to nomadic herders through the "National 100,000 Solar Ger Electrification Program". This project has brought portable solar home systems, delivering electricity for lighting, television, radio, charging mobile phones, and small appliances, to half a million people: Equivalent to half the rural population and 70% of herders (Jayawardena et al., 2012). Although Mongolia is progressing in relation to rural electrification with clean energy to individual homes in this manner, grid electrification can still bring large benefits, particularly at the community level. For example, it can provide large amounts of power for clinics, businesses, and schools, and offer electricity to non-Ger type housing. With the combination of off- and on-grid electricity through the solar Gers and ASG grid expansion, Mongolia can enjoy potable electricity applications and larger-scale equipment and application facilities for everyday life.

Possibilities to connect national grids and implications on country level

Feasibility of interconnections

In considering integration of national grids, issues concerning energy security come to the forefront. China, South Korea, and Japan, which would become major importers that rely on Mongolia and Russia for some of their energy needs, are concerned that electricity could be cut off in unforeseen circumstances.

One of the issues that must be considered when discussing risks associated with electricity procurement from abroad is the question of energy self-sufficiency. South Korea and Japan have extremely low self-sufficiency. When it comes to primary energy, Korea and Japan are only 2.5% and 4.9% self-sufficient, respectively. The two nations currently obtain most of their energy sources from other countries.

Table 4-12: Primary energy self-sufficiency (2010) Source: IEA (2012c) and IEA (2013)

	Korea	China	Russia	Japan	Mongolia
Total energy self-sufficiency	2.5%	90.6%	177.9%	4.9%	457,1%
(Including Nuclear)	17.9%	91.4%	184.3%	19.5% (2011: 11.2%)	457.1%

South Korea and Japan procure at least 90% of their fossil fuels from foreign nations and rely on imports for all the uranium used for nuclear reactors. Thus, even if they start importing electricity from Mongolia or Russia as a result of this project, their energy dependence will not change much. In addition, because natural gas and oil mainly come from the Middle East (Japan imports approximately 90% of oil from the Middle East), the importation of electricity from Mongolia or Russia will help Korea and Japan to diversify the energy supply. It should also be emphasised that the integration of electricity grids under ASG would make it possible for the participating nations to expand their renewable energy use. That, in turn, would help the countries raise their energy self-sufficiency.

Second, the amount of electricity provided under this project would be less than 10% of the total supplied to each nation. Thus, if there is a supply interruption, the member nations would still be able to make up for the shortfall with their own backup power sources. For example, the project would provide 10 GW of electricity to Japan, which is 3% of Japan's 300 GW total power capacity expected in 2030. Because Japan has a reserve capacity of at least 3% already, the country would still have enough electricity if power imports are interrupted due to unforeseen circumstances. At the same time, the average annual facility use at PV and wind power plants in the Gobi Desert is expected to be about 30%. That means Japan would import 3 GW of electricity, further reducing the risk of supply interruptions. Furthermore, electricity, unlike fossil fuels, can only be exported to countries with a power transmission infrastructure. Therefore, supply interruptions would affect the economy of not only the importing countries but also the exporting countries. This creates interdependence among the nations and prevents any one nation from having strong bargaining powers. When the system is properly established, the energy security risks of the importing nations can be mitigated.

Third, as mentioned in Chapter 3, there are ways to manage risks associated with a regional supply arrangement. One such method is the use of the EC or other international agreements. Under such a framework, the participating nations can create rules concerning investment protection, fix penalties on exporting countries that caused supply interruptions, as well as fix the quality of electricity and the way in which it should be supplied. Rules on the operation of transmission lines, such as how to cope with emergency situations, can also be established. These efforts would make it possible for the participating nations to ensure steady supplies of electricity.

Influence on national electricity systems and markets

This section analyses the potential impact that this project may have on the power generation system and the electricity market of the participating nations. First, its impact on the power generation system may be limited, because the project provides less than 10% of the generation capacity of each participant, as shown in Table 4–14. Yet, considering that South Korea and

Japan currently do not have any cross-border transmission line, they would need to establish rules and regulations concerning product quality. Under this project, importers would receive base current constantly at a certain level. Therefore, the importing nations would have to configure their domestic power generation facilities in line with the new supply rules.

Table 4-13: Generation capacity and importing electricity under the project. Source: data submitted by the project partners

	Korea	China	Russia	Japan	Mongolia
Total Capacity in 2030	159 GW	1,869 GW	249 GW	296 GW	1.7 GW
Importing Electricity by the project	15 GW	75 GW	-	10 GW	1 GW
Percentage of importing electricity against total capacity	<10%	<4%	-	< 3%	-
Current status of cross-border transmission lines	No	Yes	Yes	No	Yes

The impact that this project may have on the existing power market of participating nations depends a lot on how the new regional market is created. There are two ways to establish a regional power market – the creation of a new common market by the participating nations (the Northern European, or Nordpool type) and the linkage of existing markets of each nation (the U.S. and Canadian type). The former approach requires the participants to agree on certain trading rules and on the establishment of a power exchange. The latter does not require the establishment of an exchange. Instead, it calls for the creation of rules and regulations that would allow power generators and purchasers of each nation to participate in one another's markets once these markets are linked. Another possibility is to create a system in which the project operator trades directly with purchasers of the participating nations. Regardless of which method is used, a system must be in place to guarantee TPA to the countries' power transmission operations so that foreign companies can participate in electricity trading on an equal footing with their domestic rivals.

Table 4-14: Current status of market liberalisation in participating countries. Source: JEPIC (2011)

	Korea	China	Russia	Japan	Mongolia
Wholesale Market	Yes	No	Yes (partially)	Yes (partially)	Yes
Market Share of IPP	6.0% (2011)	-	-	3.5% (2012)	-
Unbundling	No	Yes	Yes	No	Yes

The following is a summary of the current market situations of each nation:

South Korea

South Korea requires six power generation subsidiaries of the Korea Electric Power Corp. as well as IPP to join the Korea Power Exchange. Most electricity is traded through the power exchange, although some power is sold directly to a South Korean power provider (KEPCO) under a long-term contract. Under its "cost-based pool" system, the exchange calculates expenses based on the different characteristics of each generation facility that determines the wholesale prices. There is a distinction between base-load power sources and non-base-load power sources and their prices are determined accordingly. (This system differs from the conventional wholesale trading mechanism under which power generators submit bids.) Large users are legally allowed to buy power directly from the market without going through KEPCO. In practice, however, KEPCO is the only supplier in the market because it offers low rates for large users. In addition, KEPCO monopolises the country's power transmission operations. So far, the country has no electricity transactions with foreign nations.

China

In China, there are 3,800 power generation companies. They include the five biggest power suppliers: Those owned by State-run coal and investment companies, nuclear power operators, hydroelectric companies, and power generators owned by local governments. As for power transmission and retailing, there are two distribution companies that handle most of the work, except for regional off-grid areas. China also buys some electricity from Russia and trades power with neighbouring nations, such as Mongolia, North Korea, and Vietnam.

Russia

In Russia, power generation is considered a competitive industry. All power producers, except for the government-run nuclear and hydroelectric power companies, are privately operated. These comprise six power generation wholesalers with large thermoelectric plants (OGKs) and 14 territorial power generation companies (TGKs). Major European power companies also operate in Russia. On the other hand, T&D operations are a "natural monopoly". The following companies are under government control: OAO SO-CDU EES (SO), the grid operator, OAO FSK-EES (FSK), the federal power transmission company and MRSK Holding, the distribution holding company. Meanwhile, Inter RAO EES, the federal power transmission company which specialises in trading with companies in other countries, also participates in the wholesale market as a buyer and supplier. The Far Eastern region is an exception to this arrangement; the power industry is still under the direct control of the government. Exports account for a small percentage of the total power production. Russia also buys some electricity from abroad.

Japan

In Japan, the industry is vertically integrated, with 10 regional monopolies providing power generation, transmission, and retail distribution services. The market has been gradually deregulated since 1995. New entrants can now participate in the wholesale market and large-lot users are allowed to enter the retail market. However, the total market share held by new market entrants is only about 3%. Transactions conducted through the Japan Electric Power Exchange are less than 1% of the overall trading volume. Thus, the industry needs further reform. In 2016, the country is seeking to fully deregulate the retail sector and to separate power companies' transmission operations as independent entities (through what is known as legal unbundling). So far, the country has no electricity transactions with foreign nations.

Mongolia

Mongolia has four power systems – Central Energy System, Western Energy System, Eastern Energy System, and Altai Uliastai Energy System. The central energy service (CES) provides more than 90% of the power used in the nation. Under the system operated by the CES, the Central Electricity Transmission Network, the sole buyer, purchases electricity at prices determined by the Energy Regulatory Authority, which sets separate prices for each power facility. The Central

Electricity Transmission Network then sells power to distribution companies. The country's electricity spot market and the wholesale market were opened in 2005 and 2007, respectively, by the central power supply command centre. At the wholesale market, power producers submit prices and the volume of excess electricity they seek to sell. Meanwhile, CES imports 13% of the power used in Mongolia from a supply network in Russia. Mongolia also procures electricity directly from China for use at a mineral mine.

Conclusions

In this chapter, we analyse various benefits that Gobitec and ASG can bring specifically to Mongolia, and to all other participating countries of the project. Benefits are of an economic, social and environmental kind. Regarding economic benefits, the project can yield multiple possibilities for job creation in Mongolia through manufacturing, construction, operation and maintenance tasks. Based on simple preliminary analysis, the industry as related to the project of 100GW PV and wind can lead to the creation of up to 900,000 new jobs in Mongolia from 2015 to 2030. In addition to the job creation effect in Mongolia, the project will bring economic benefits to the participating countries through cost savings of electricity and increase flexibility of grid systems.

In regard to social and environmental benefits, significant benefits would be the CO_2 emission reduction effect of the project. By importing renewable electricity from the project, the participating countries can decarbonise their energy mix. Using an uncomplicated estimation, total emission reduction can reach 187 Gt CO_2 per year. Conclusion: Maximising International and Regional Cooperation

CONCLUSION:
Maximising International and Regional Cooperation

The following chapter gives an overview on the recommendations and actions that can be derived from this study at the present stage of research. The chapter will start with an introduction and include a presentation of the general procedure and risks of the megaproject, Gobitec. Based on this introductory study, the next part will describe the overall targets that have been identified. Then conclusions will be presented on the project and on the present situation.

Gobitec – the risks and opportunities of megaprojects

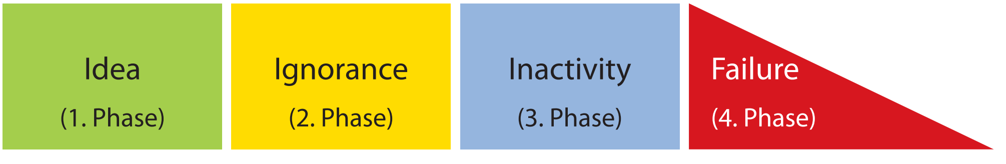
Before starting to give any policy recommendations on a project like Gobitec, a warning should be delivered: Gobitec is, at its present state, a vision. Sovacool and Cooper call it a miracle which could – in theory – solve a lot of problems in the region: Satisfying the increasing electricity demand, possibly improving international affairs between South and North Korea, generating additional revenue to countries like Mongolia and trying to prevent Japan and Korea from playing the nuclear card in the game of electricity supply. These are bold assumptions.

When looking at various megaprojects, it is often clear that they follow a specific path. These megaprojects can be divided into four phases. In the first phase megaprojects tend to start with an appealing and assumingly brilliant idea. In this case the "idea" is to establish RES in the Gobi Desert or along the planned ASG.

This idea leads to analyses and studies. During this pioneering phase great enthusiasm can lead to first results. This first period is often characterised by "optimism bias". This effect describes the optimistic view in the early stage of a megaproject, which is retained to avoid internal conflicts.

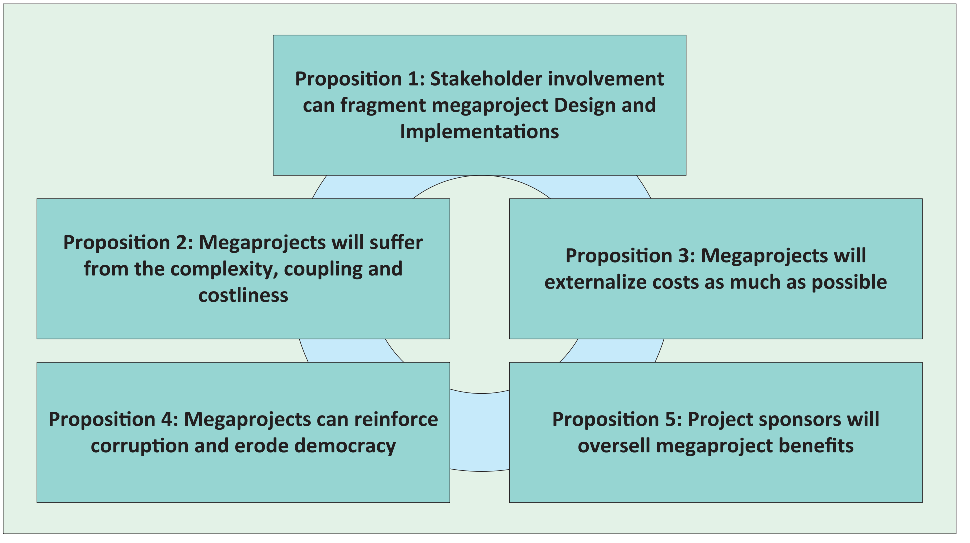
However, the complexity of such a huge project is often underestimated. A suitable legal and policy framework should be developed, financial and regulatory aspects must be negotiated between the different stakeholders and the diverse technological challenges must be addressed. This leads to phase 3. During this phase some critical problems and challenges are ignored and not dealt with until they become overwhelming. In the last phase partners get confronted with these issues and often become discouraged.

Figure 5-1: The three I's



Sovacool and Cooper have dealt with different megaprojects and have identified five propositions from the "economical", "politics/governance" and "engineering" sector (see Figure 5-2). The propositions appear very uncomfortable but need to be dealt with.

Figure 5-2: "5 Propositions of megaprojects" (Sovacool and Cooper 2013)



The 1st proposition states that with the increasing number of participants the conflict potential rises. In consideration of other megaprojects like DESERTEC and the conflict between the industrial initiative and the foundation, this problem should be taken into account. Considering Gobitec and the ASG in association with all the participating countries and other stakeholders, this problem can be decisive. Diverse or inactive initiatives as described in Chapter 3 indicate that the "energy region" where the Gobitec and ASG project is planned to be implemented already shows components of over complexity.

The 2nd proposition noted that megaprojects can suffer under the inherent complexity, thus presenting a danger for the Gobitec and ASG project. As shown in Chapter 2-of this study, the technological concept as a whole is very complex. The electricity production along the ASG, and the implementation of policies into national energy systems and the handling of fluctuating RES present a great challenge. Therefore, it is arguable whether the project can be divided into national or bilateral projects in the first phase, while the overall Gobitec vision would be used as a target picture.

The 3rd proposition is that the initiators of megaprojects will try to externalise costs as much as possible, while the benefits will be reallocated to a small minority. The reasons behind this proposition are twofold: The first reason is that the stakeholders may willingly try to reduce their obligations and displace the risk potential; the second reason is that, based on initial analysis, the technological complexity was underestimated and led to unconscious externalisation. An example is concentrated solar power plants which need a high direct nominal irradiance achieved in the deserts, but on the other hand, need a lot of cooling water, depending on the cooling process. This water must then be retrieved from reservoirs or aquifers. This imparts a high burden on land sustainability. However, this development of externalisation is not avoidable. It is still possible with "better knowledge" to reduce the externalisation process. One example is the planned 2 GW CSP plant in Tunisia, where waste water from olive tree plantations is used to cool the process.

The 4th proposition, formulated by Sovacool and Cooper, is that megaprojects tend to foster corruption and erode democratic processes. The theory indicates that highly concentrated decision processes with small groups of decision makers tend to foster corruption as the overall processes are intransparent to the external groups. Consequently, decision processes in the Gobitec and ASG project should be kept open and studies and results made public with the aim of creating a communication platform that has a strong moderation theme. As mentioned before, such a procedure can be started on a regional or national level in order to determine the objectives and needs of not only the stakeholders but also of other affected groups.

The last proposition mentions the overselling of benefits of the megaproject by the stakeholders, resulting in overestimated expectations. This is indeed an important issue and, important in the early stage of the Gobitec and ASG vision. This means that the analysis, results and discussion should be made transparent to allow the public to have additional control.

But the question is: *Does it makes any sense after the disillusioning beginning of this chapter to think of a Gobitec or ASG vision?* It depends. The research done at this early stage is merely an approximation showing the possible and theoretical potential. It identifies the technologies that could be used and implemented into the system. At this early stage there is no detailed potential analysis for renewable energies available for the whole region. Definitely more research has to be done and discussions between the governments have to take place to estimate if the vision can become a reality.

The following subsections will describe the policy recommendations based on the present state of analysis.

Status quo and further procedure

In this section the status quo of the Gobitec and ASG project will be discussed. As a next step the general procedure for handling megaprojects will be described, following the recommendations of Edward Merrow.[27]

Based on the results and workshop held during this project, the following SWOT matrix (strength, weaknesses, opportunities and threats) was developed:

[27] *Merrow, E. (2011): Industrial Megaprojects: Concepts, Strategies, and Practices for Success. Hoboken, NJ.*

Table 5-1: Gobitec/ASG SWOT Matrix

Strengths - Huge theoretical potential in the Gobi Desert (but also in South Korea and Japan) - Provide energy in an integrated system - Increase renewable energy rates - Increase energy security and safety due to a larger energy system - Facilitate energy and political cooperation	**Weaknesses** *- Huge capital costs (The "one" project)* - Difficult geopolitical constellation - Technical issues on HVDC transmission and solar energy system (CSP/cooling system) - Land availability especially for transmission lines and partly for the plant deployment
Opportunities - Activate further policy cooperation - Larger economic and political integration - Local manufacturing potential - Attract foreign and private investors towards Northeast Asia - Economic benefits through local manufacturing - Reduce air pollution - Research opportunities (Asian Dust) - Cut down CO2 emissions - Stepwise build-up securing local demand first - Participation of the local population	**Threats** *- High capital risks* - Necessity of political cooperation and rivalry between the countries (already several failed initiatives) - Induce water shortage through some renewable energy technologies - Threaten the lifestyle of nomadic tribes in Mongolia

So far the general opinion based on the desk research and basic modelling is that there definitely is a huge potential for RES in the Gobi Desert area. However, it has to be proven and analysed how large exactly the economic potential is and how the planned RES can be implemented into the overall systems of the different countries. This is only possible with an integrated system modelling approach. Similar studies have been done for the Deserter studies by the Dii or later by Fraunhofer. For the Gobitec and ASG project, the technical potential is not known in detail, but the first wind park in Mongolia can serve as a reference: With 50 MW capacity, an average wind speed of 8.4 m/sec, more than 3,000 full load hours and generation cost of around 8 US$ cent, the wind potential is promising[28]. In addition, this high wind potential is located close to demand centres.

Definitely the deployment of the planned 100 GW capacity of renewable energies can raise the share of renewable energy electricity in the participating countries and therefore lower the CO_2 emissions. The next step will analyse if this objective can be achieved by national or bilateral strategies and the differences between different strategies need to be analysed. One of the main threats and weaknesses identified is the huge capital cost of nearly 500 billion US$. On the other hand, the capital risks are high, as they depend on complex technological systems and government agreements. As past initiatives proved to be inactive or not working for several years, this concern has to be considered. As the capital required cannot be raised in its entirety by private investors, the first phase will require venture capital to support the investment.

A further opportunity of the Gobitec and the ASG project is the potential to develop local industries and open up new opportunities within the participating countries.

Based on the status quo, a further set of actions need to be set up. In the first place, this study's results should be disseminated among the participating governments and other stakeholders.

[28] *On site project data / National Renewable Energy Center of Mongolia*

However, the results achieved so far are basic and in a development stage. Further analysis should be done and designs for the different focus topics should be developed in order to proceed with the project.

Research and actions should be developed in two main areas: The technological and thematic working groups.

The technological analysis should focus on the technical feasibility, analysing the renewable energy potential and the implementation of the Gobitec and ASG project in the existent systems within the countries. In this analysis, a target picture should be developed to identify political objectives. These results should then be used to discuss a target and objective framework at a political or government level.

Alongside this development, the dialogue between the participating countries and international organisations (e.g. the EC) should be started to consider the accession of all countries of NEA to a common legal framework, the ECT. This legal framework should regulate investment, trade, transit and dispute resolutions between the different countries. A detailed description on this topic can be found in Chapter 3.

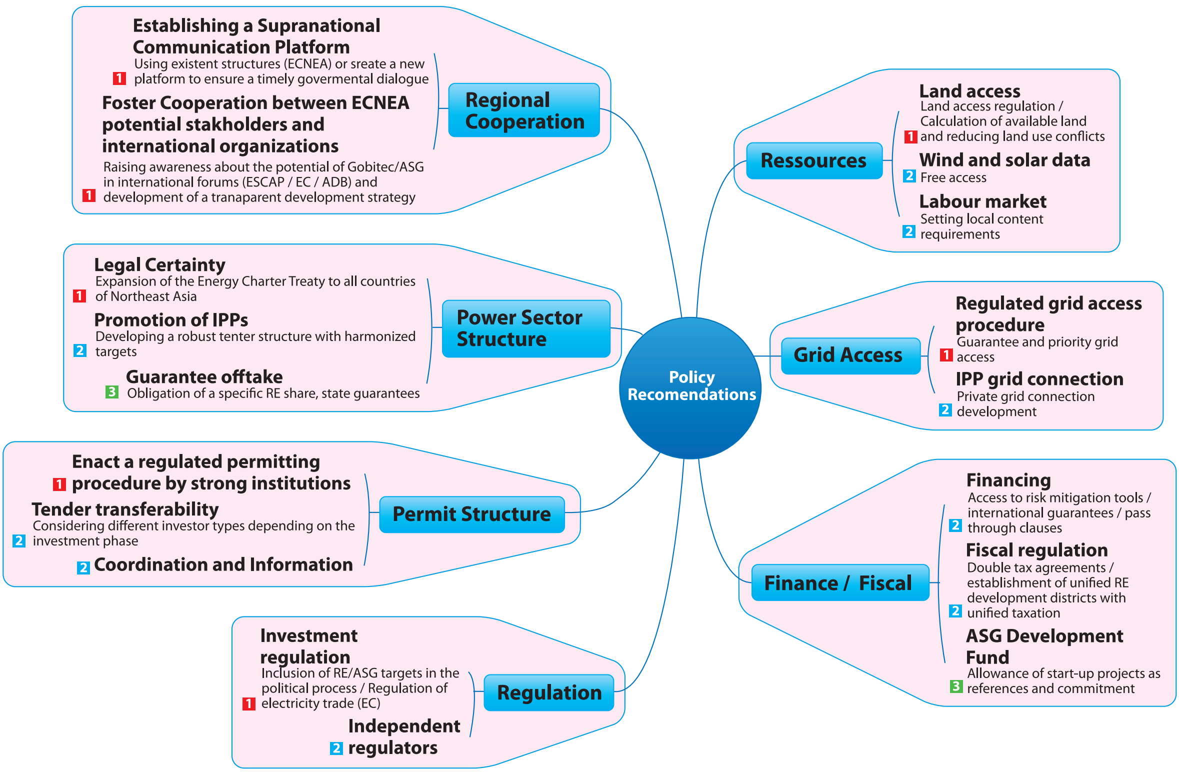
Figure 5–3: Shows the Overall and priority targets divided between the Gobitec and ASG project ideas

Figure 5-3: Gobitec/ASG overall targets

Actions to support the Gobitec and ASG vision

In the previous chapter, among other considerations, the main objectives of the project ideas were described. A more detailed perspective is now given of the actions needed to support the Gobitec and ASG idea. Figure 5-4 shows the actions recommended. The actions are classified into thematic groups. The numbers next to the different actions show the priority of a product of the workshop discussions and desk research in relation to the project. The order in which the action groups will be discussed gives an orientation of the time frame needed for the project.

Figure 5-4: Actions to support Gobitec/ASG



The first group and one of the most important is the "Regional Cooperation" group. The main action here is to establish a supranational communication platform and to begin negotiations between the different stakeholders. The main objective is to identify the different targets of the participants and determine a convention on further negotiations. Within this platform other megaprojects and the experiences encountered should be considered; here too specific task groups can then start to negotiate the first level of legal implementation, described by the two groups: "Power Sector Structure" and "Grid Access". It is within these two groups that the legal certainty related to power exchange and transmission should be discussed. Solutions have to be found not only for large institutional investors but also for IPP. The latter are necessary to enable small investors, which tend to be more innovative and adapt to new technologies faster, to invest and participate in these developments. Additionally, implementing these IPP adds a supplemental stakeholder and raises the acceptance because of broader participation.

Parallel to the observations described above is a group that justifies collective decisions on the detailed analysis of the resources and technological feasibility. In this group, on the one hand, the detailed potential analysis and the technological implementation should be evaluated; and on the other, the availability of other resources such as labour force and local manufacturing potential should be assessed. The results of these studies will be communicated transparently to help the stakeholders make decisions on policy implementation.

The last group represents the continuative sharpening of the legal framework. It consists of the "Permit Structure", "Finance/Fiscal" and "Regulation" design. Within these thematic groups, operative factors should be determined; empowering and regulative structures should be designed in a transparent way to avoid the overreaching of limited stakeholder groups. In the finance framework, two groups are relevant: The first group centres on the regulation and creation of a financial framework. As the participating countries are heterogeneous, the creation of joint economic districts, where unified rules are pertinent could be applied. The next important group represents government support instruments for renewable energy deployment. This instrument can be a development fund which supports projects within the Gobitec and ASG framework.

Conclusions

As the study is a first analytical approach to determine the potential of the Gobitec and ASG project, it is difficult to develop clear policy recommendations or a master plan which can serve as a blueprint. Therefore, the recommendations made are rather general. They show, however, the complexity of political implementation of megaprojects. Denying this complexity might lead to an overall biased picture.

The most important message of this chapter is that two main activities are needed to be in place to foster the project: The first is further research on the potential and integration of Gobitec and ASG into the national electricity systems and strategies. The second is the development of a fair legal framework. The legal framework is important in order to create transparent and fair rules for the electricity exchange and transmission conditions.

Together, both main objectives are able to reduce the risk and, therefore, raise the probability to attract investors.

To enlarge the group of beneficiaries and increase the acceptance, it is also important to open up the project not only for institutional investors but also for IPP. Hence, in designing the Gobitec and ASG project, the renewable energy capacity can be divided into smaller scale projects which are aligned around the ASG. These projects, whether national or bilateral, may help to assess the developed legal framework.

REFERENCES

Bahar, H. and Sauvage, J. 2013. 'Cross-Border Trade in Electricity and the Development of Renewables-Based Electric Power: Lessons from Europe', *OECD Trade and Environment Working Papers*, February 2013, OECD Publishing.
http://dx.doi.org/10.1787/5k4869cdwnzr-en

BMU (German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety). 2008. *Short- and Long-Term Impacts of the Expansion of Renewable Energy on the German Labor Market, Second Report on Gross Employment.*
https://secure.bmu.de/fileadmin/Daten_BMU/Pools/Broschueren/EE_Beschaeftigt_eng_bf.pdf

BP. 2013. *BP Statistical Review of World Energy.*
http://www.bp.com/en/global/corporate/about-bp/statistical-review-of-world-energy-2013.html

Breitschopf, B., Nathani, C. and Resch, G. 2012. *Economic and Industrial Development: EID – EMPLOY, Methodological guidelines for estimating the employment impacts of using renewable energies for electricity generation.* Prepared for the IEA RETD.
http://iea-retd.org/wp-content/uploads/2012/12/EMPLOY-Guidelines.pdf

California's Clean Energy Future. 2012. California renewable energy overview and programs
http://www.energy.ca.gov/renewables/, Accessed 3 October 2013.

Costs and Benefits, *An IEG Impact Evaluation.* Available at
http://lnweb90.worldbank.org/oed/oeddoclib.nsf/DocUNIDViewForJavaSearch/EDCCC33082FF8BEE852574EF006E5539/$file/rural_elec_full_eval.pdf

Dii, June 2012. 2050 Desert Power – *Perspectives on a Sustainable Power System for EUMENA.*
http://www.dii-eumena.com/dp2050/desert-power-2050.html

Eurelectric, October 2011. *Flexible Generation: Backing up Renewables.*
http://www.eurelectric.org/media/61388/flexibility_report_final-2011–102–0003–01-e.pdf

European Photovoltaic Industry Association (EPIA) and Greenpeace, 2008. *Solar Generation V – 2008: Solar electricity for over one billion people and two million jobs by 2020*

European *Renewable Energy Council, 2008. Renewable Energy Technology Roadmap 20% by 2020.*
http://www.erec.org/fileadmin/erec_docs/Documents/Publications/Renewable_Energy_Technology_Roadmap.pdf

European *Wind Energy Association (EWEA), 2009. Wind at work. Wind Energy and Job Creation in the EU.*
http://www.ewea.org/fileadmin/ewea_documents/documents/publications/Wind_at_work_FINAL.pdf

IEA (International Energy Agency), 2011. *Harnessing Variable Renewables - A Guide to the Balancing Challenge*. OECD Publishing

IEA, 2012a. *World Energy Outlook 2012*

IEA, 2012b. *IEA* CO_2 *Emissions from Fuel Combustion 2012*

IEA, 2012c. *Energy Balances of non-OECD Countries 2012 Edition*

IEA, 2013. *Energy Balances of OECD Countries 2013 Edition*

ILO (International Labor Organization), 2009. *Key Indicators of the Labor Market.* 6th edition.

Jayawardena, M.S., Rivera, S. and Ratnayake, C. 2012b. *Capturing the Sun in the Land of the Blue Sky: Providing Portable Solar Power to Nomadic Herders in Mongolia.* http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2012/09/20/000356161_20120920022339/Rendered/PDF/726830WP0P09930per0v2.300Imagebank0.pdf

JEPIC (Japan Electric Power Information Center), 2011. *The Electric Power Industry in Foreign Countries.*

Lantz, E and Tegen, S. 2011. *Jobs and economic development from new transmission and generation in Wyoming.* NREL report. March.

Miller, M.L., Bird, J., Cochran, M. and Milligan, M. Bazilian. *National Renewable Energy Laboratory.* E. Denny, J. Dillion, J. Bialek, M. O'Malley from Escar Limited, K. Neuhoff from DIW Berlin. July 2013. RES-E-NEXT- Next Generation of RES-E Policy Instruments, http://iea-retd.org/wp-content/uploads/2013/07/RES-E-NEXT_IEA-RETD_2013.pdf

Rutovitz, J. and Atherton, A. 2009. *Energy sector jobs to 2030: a global analysis.* Prepared for Greenpeace International by the Institute for Sustainable Futures, University of Technology, Sydney.

Rutovitz, J. and Usher, J. 2010. *Methodology for Calculating Energy Sector Jobs.* Final report, http://www.isf.uts.edu.au/publications/rutovitzusher2010jobsmethodology.pdf

Savacool, B.; Cooper, C. (2013): The Governance of Energy Megaprojects: Politics, Hubris and Energy Security. MA.

Wei, M., Patadia, S. and Kammen, D.M. 2010. 'Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US?' *Energy Policy* 38: 919–931.

World Bank, 2008. The Welfare Impact of Rural Electrification: A Reassessment of the costs and benefits.
http://go.worldbank.org/P9RKZP7Z20, Accessed October 3, 2013.

World Bank, 2012a. 'Poverty Level Estimated at 29.8% in Mongolia'. Press Release, April 17, 2012. http://www.worldbank.org/en/news/press-release/2012/04/17/poverty-level-estimated-at-nearly-30-percent-in-mongolia, Accessed October 3,2013.

World Bank. 2013. *Regional aggregation using 2005 PPP and $1.25/day poverty line.* http://iresearch.worldbank.org/PovcalNet/index.htm?1, Accessed October 3, 2013.

DEFINITIONS

ADB	Asian Development Bank
ADO	Asian Development Outlook
AEH	Asian Energy Highway
ASEAN	Association of Southeast Asian Nations
ASG	Asian Super Grid
APEC	Asia–Pacific Economic Cooperation
APNet	Asia–Pacific Network
BAU	Business as Usual
BTB-DC	Back-To-Back DC
bn	Billion
CES	Central Energy Services
CO_2	Carbon Dioxide
CONEXO	Consolidation, Expansion and Outreach
CRF	Capital Recovery Factor
CSE	Central Energy System
CSC	Current Source Converter
CSP	Concentrating Solar Thermal Power
DC	Direct Current
DII	Desertec Industrial Initiative
DNI	Direct Normal Irradiation
DOE	Department of Energy
EC	Energy Charter
ECNEA	Intergovernmental Collaborative Mechanism on Cooperation in Southeast Asia
ECS	Energy Charter Secretariat
ECT	Energy Charter Treaty
ERIA	Economic Research Institute for East Asia
ESI	Energy Systems Institute of the Russian Federation
FC	Fixed cost
FCR	Fixed Cost Ratio
FDI	Foreign Direct Investment
FTA	Free-Trade Agreement
GATT	General Agreement on Tariffs and Trade

GTO	Gate Turn-off Thyristors
GW	Generation Capacity (gigawatt)
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
IEEE	Institute of Electrical and Electronics Engineers
IPP	Independent Power Producers
IPR	Intellectual Property Rights
IRENA	International Renewable Energy Agency
ISE	Institute for Solar Energy Systems Fraunhofer
ISI	Institute for Systems and Innovation Research Fraunhofer
JEDI	Jobs and Economic Development Impact
JREF	Japan Renewable Energy Foundation
KEEI	Energy Economics Institute of the Republic of Korea
KERI	Korea Electrotechnology Research Institute
km	Kilometre
kV	Kilovolt
kW (h)	Kilowatt (hour)
LCC	Life Cycle Cost
MFN	Most-Favoured National Treatment
MW (h)	megawatt (hour)
MoE	Ministry of Energy of Mongolia
NREL	National Renewable Energy Laboratory
NEA	Northeast Asia
O&M	Operation and Maintenance
PCC	Power Connection of Common Coupling
PCS	Power Conditioning System
PEEREA	Protocol on Energy Efficiency and Related Environmental Aspects
PTP-DC	Point-To-Point DC
PV	Photovoltaic
RCS	Regional Collecting Station
RES	Renewable Energy Sources
RTA	Regional Trade Agreements

SRCS	Subregional Collection Station
T&D	Transmission and Distribution
TCS	Total Collecting Stations
TOT	Transfer of Technology
TPA	Third-party Access
TSUC	Total Supply Unit Cost
TW	terrawatt
TWh	terrawatt hour
UHVDC	Ultra-high Voltage Direct Current
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations framework convention on climate change
VC	Variable Costs
VSC	Voltage Source ConverterVariable
VRE	Renewable Energy
WAEC	Weighted Average Electricity Charges
WTO	World Trade Organisation

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