IRENA
International Renewable Energy Agency

MONGOLIA

RENEWABLES READINESS ASSESSMENT

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IRENA
International Renewable Energy Agency

About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

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MONGOLIA

RENEWABLES READINESS ASSESSMENT

FOREWORD
from the Minister of Energy

We are pleased to announce the release of this Renewables Readiness Assessment as a policy document for the Ministry of Energy of Mongolia, prepared in co-operation with the International Renewable Energy Agency (IRENA).

The State Policy on the Energy Sector, approved by parliament and published in 2015, determined short- and mid-term development scenarios and set an ambitious goal of increasing the contribution of renewable energy to the country's total installed power-generation capacity to 20% in 2023 and 30% in 2030.

To achieve these goals, the existing laws on energy and renewables have been amended, while parliament has recently approved the new Law of Mongolia on Energy Conservation and Efficiency. This new legislation enables Mongolia to provide energy security and reliability, improve energy efficiency, pursue public-private partnerships and create a market-oriented framework for the sector.

Mongolia's Gobi Desert is enormously rich with solar and wind resources. Additionally, the country's considerable hydropower, geothermal and biomass resources can be exploited for greater energy supply.

The opportunities to create value from such vast, naturally available, renewable resources are numerous, particularly with modern capture and distribution technologies. For a country like Mongolia, with its wide geographic expanse and low population density, advanced renewable energy technologies are essential to accelerate economic growth, support development and ensure future prosperity.

We have set key goals to utilise the Gobi Desert's vast resources:

- Construction of a large-capacity renewable energy complex, aiming to export power to north-eastern Asian countries;
- Co-operation with neighbouring countries to implement the renewable energy complex;
- Establishing a mutually beneficial long-term agreement for imports and exports of power between neighbours;
- Strengthening our co-operation with international organisations and donor countries;
- Attracting investment.

We are fully committed and are working gladly to achieve these goals.

We would like to express our sincere gratitude to IRENA for accepting the proposal of the Government of Mongolia to jointly develop this assessment of our country's readiness for accelerated renewable energy deployment. Having set out to develop renewables as a leading sector in Mongolia's economy, we greatly appreciate the assistance provided by IRENA and the contributions of experts and scholars in developing this important policy document.

H.E. Zorigt Dashzeveg
Minister of Energy, Mongolia

FOREWORD
from the IRENA Director-General

Mongolia has firmly underlined its commitment to green growth and a sustainable energy future, particularly in support of international efforts to address climate change. With abundant solar, wind and hydropower resources, the country possesses the renewable assets to adapt to changing realities, such as increased constraints on carbon emissions, and to replace its business-as-usual approach with a sustainable development paradigm.

The country's Renewables Readiness Assessment (RRA), undertaken in co-operation with IRENA, has identified key actions to unlock or accelerate renewable energy deployment. It is the result of a process that brings together different national and international stakeholders for a series of country-led consultations, with IRENA providing technical support and expertise.

Since 2011, more than 20 countries in Africa, the Middle East, Latin America and the Caribbean, as well as the Asia-Pacific region, have undertaken the RRA process, which generates knowledge of best practices and supports international co-operation around the accelerated deployment of renewable energy technologies. Mongolia, a strong supporter of IRENA's mission, is one of those countries.

As technology costs fall and the demand for renewables continues to grow, Mongolia can make increased use of its highly varied potential in the sector, including solar, wind, and large and small hydropower, as well as geothermal and biomass resources. All of these can help to ensure a reliable, affordable supply of energy, which would in turn help address growing energy demand and support economic growth. Exports of clean, renewable-based electricity offer the prospect of sustainable revenue for the country, and Mongolia has taken the initiative to promote regional cooperation that can make this a reality.

The country's amended renewable energy law and its state energy-sector policy provide the right foundations to attract stable investment. Revised renewable energy targets would increase the contribution of renewables to 20% of total installed power-generation capacity by 2023 and 30% by 2030. These have sent a clear, positive signal of Mongolia's ambition to the international community, as well as to investors and developers. Still, more can be done to ensure a successful energy transition.

With the adoption of the Paris Agreement at COP 21, as well as the Sustainable Development Goals by the United Nations General Assembly, the imperative of a transition to sustainable energy systems will continue to grow, and along with it the momentum driving the scale-up of renewables.

I sincerely hope the present study provides further encouragement for accelerated deployment. IRENA stands ready to provide continuing support, both in implementing the actions identified and in the country's broader pursuit of a sustainable energy future.

This study has benefited from the strong support of Mongolia's Ministry of Energy. Other governmental agencies have also participated actively, and their insights are greatly appreciated. In addition, various stakeholders within the country have provided enthusiastic and serious engagement, without which the process could not have delivered the desired results. I would like to express my appreciation to all participants and encourage them to continue their valuable work.

Adnan Z. Amin
Director-General, IRENA

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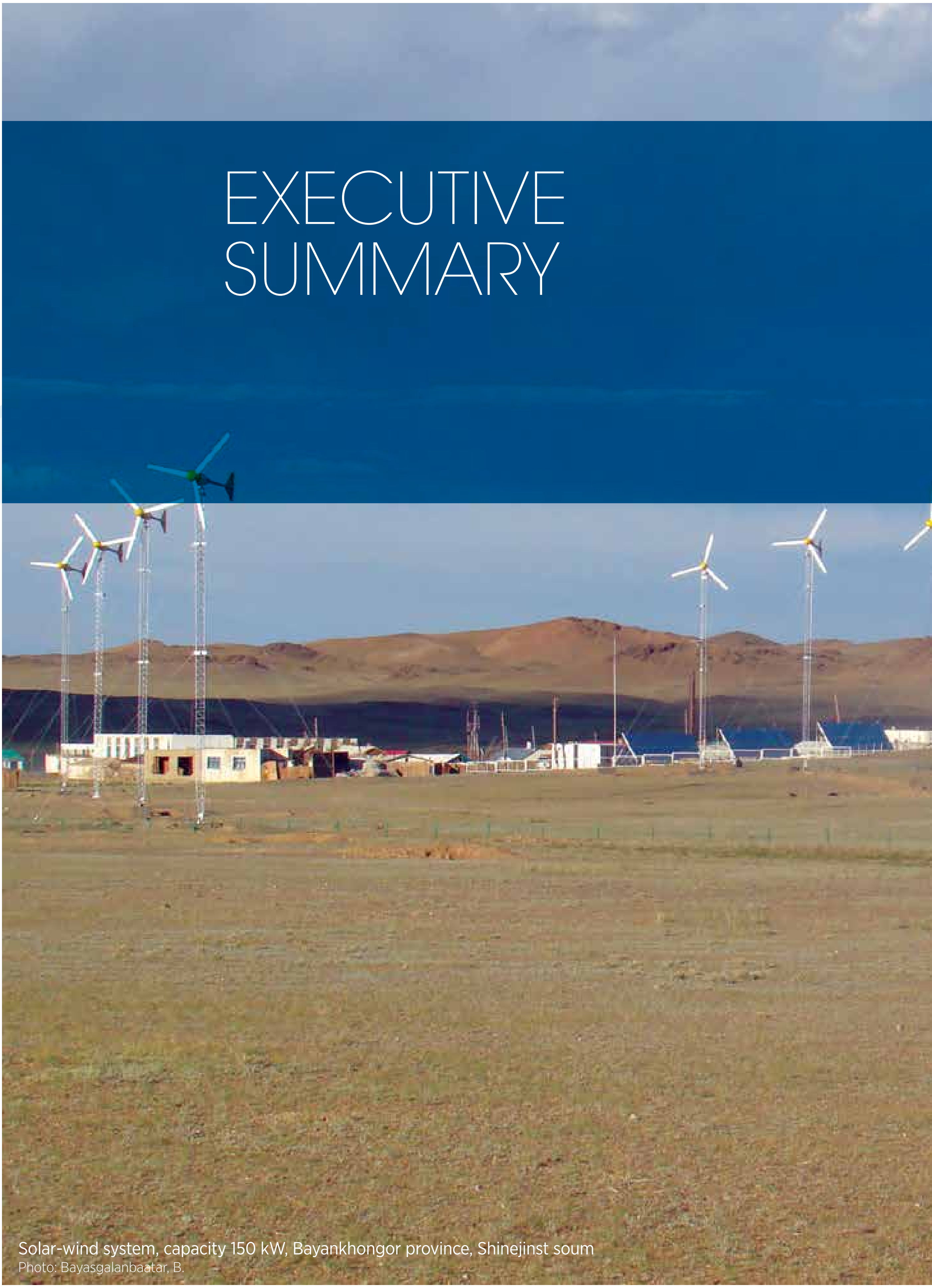
ABBREVIATIONS

ADB	Asian Development Bank
ASG	Asian Super Grid
CDM	Clean Development Mechanism
CES	Central Energy System (Mongolia)
CHP	combined heat and power
ERC	Energy Regulatory Commission (Mongolia)
FiTs	feed-in tariffs
GDP	gross domestic product
GHG	greenhouse gases
GW	gigawatt
GWh	gigawatt-hour
HVDC	high-voltage direct current
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contribution
IPP	independent power producer
IRENA	International Renewable Energy Agency
km	kilometres
kV	kilovolt
kW	kilowatt
LPG	Liquefied Petroleum Gas
MEGD	Ministry of Environment and Green Development
MEGDT	Ministry of Environment, Green Development and Tourism
MoE	Ministry of Energy
MW	megawatt
ųg/m^3	micrograms per cubic metre
NAMAs	Nationally Appropriate Mitigation Actions
NDC	National Dispatching Center (Mongolia's grid operator)
NREC	National Renewable Energy Center (Mongolia)
NREL	National Renewable Energy Laboratory (US)
PPA	power purchase agreement
PPP	public-private partnership
PV	photovoltaic
RRA	Renewables Readiness Assessment
SHS	solar home system
TPES	total primary energy supply
TW	terawatt
TWh	terawatt-hour
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
Wp	Watt-peak

EXECUTIVE SUMMARY



Solar-wind system, capacity 150 kW, Bayankhongor province, Shinejinst soum
Photo: Bayasgalanbaatar, B.

Mongolia is a resource-rich country, with an abundance not of only coal, but also of renewables, such as solar, wind and hydropower resources. For several decades, coal has been the primary energy source fuelling Mongolia's rapid economic growth. However, this has come with environmental costs, particularly in urban centres and mining regions.

The World Health Organization (WHO) has listed the capital, Ulaanbaatar, as one of the five most polluted cities in the world, while the World Bank has been engaged in projects and studies to reduce the human health damage from the city's worsening air pollution. Changing global realities present an additional challenge, with carbon emissions expected to become increasingly constrained in the international effort against global warming.

In addressing these challenges, the Government of Mongolia has demonstrated a strong political commitment to green development, plotting the transition to an energy future based on higher shares of renewables for the country and wider region. Mongolia has declared a two-phase renewable energy goal, aiming to increase renewables from 7% of installed power-generation capacity to 20% by 2023, and to further increase this to 30% by 2030.

The Ministry of Environment and Green Development (MEGD), established as a core ministry in 2012, has been working closely with the Ministry of Energy (MoE) to exploit the country's enormous renewable energy resources. The 52 megawatt (MW) Salkhit wind farm that commenced operation in July 2013 was a significant milestone, marking the development of Mongolia's first utility-scale non-hydro renewable energy facility. Growing numbers of wind and solar projects are in the pipeline in response to the renewable energy targets set by the government.

Yet even if those targets are achieved, the scale of renewable power production will remain small. This reflects the limited scale of the domestic energy market, which serves around 3 million people. In comparison, the country's total renewable energy potential has been estimated at 2.6 terawatts (TW),[1] a potentially huge resource base. Combined electricity output from Mongolia's wind and solar resources could reach 15 000 terawatt-hours (TWh) per year,[2] enough to meet the total electricity demand of neighbouring China in 2030.[3]

The President of Mongolia, Tsakhia Elbegdorj, has formed the Gobitec initiative to create a regionally integrated power grid across northeast Asia. The initiative is researching solar and wind energy potential in sparsely populated Gobi Desert areas, with a view to producing power exports to China and other countries. In support of this goal, the Ministry of Foreign Affairs has set out, with strong engagement from the MoE, to strengthen co-operation with neighbours. The government has also recognised the importance of developing an enabling environment with clear and achievable targets. To achieve the president's vision, the country also needs the right set of legal, regulatory and policy frameworks, along with the necessary technical capacities for regional renewable energy deployment.

In parallel, Mongolia has stepped up efforts to improve the conditions for domestic development and deployment of renewables. The Renewable Energy Law, passed in 2007, has provided a fundamental legal basis to regulate the generation and supply of renewable power. Amid changing circumstances, parliament amended the law in June 2015. The improved legislation should strengthen public-private partnerships and create a market-oriented framework for the energy sector.

Innovative processes, including a joint credit mechanism, have been proposed to promote climate-friendly energy technologies. The State Policy on the Energy Sector provides strategic guidance to transform Mongolia into a renewable electricity exporter within two decades. By then, neighbouring countries should be able to receive Mongolian power through high-voltage direct current (HVDC) transmission lines. Domestic supply, meanwhile, will benefit from enhanced national grid networks, equipped with information technology systems for smart transmission, management, control, and monitoring.

To fully capitalise on these opportunities, key challenges must be precisely identified and addressed. With that aim, Mongolia embarked on Renewables Readiness Assessment (RRA) consultations in co-operation with the International Renewable Energy Agency (IRENA). The resulting discussions highlighted the challenges Mongolia faces with its renewable energy growth goals, and also produced viable recommendations to help overcome those challenges.

Core elements of the enabling environment

Nearly a decade after Mongolia's Renewable Energy Law was introduced, effective implementation remains a challenge, hampering the creation of the necessary enabling conditions for renewable energy investment and development. For instance, feed-in tariffs (FiTs) put into effect under the Renewable Energy Law have faced two main obstacles:

- **Limited duration of FiTs.** The original law stipulated FiTs for 10 years, which deterred investors from entering power purchase agreement (PPAs) for longer periods. Long-term price guarantees can reduce the risk associated with renewable energy investments, making bank loans easier to obtain. But the price-guarantee period needs to be long enough – an issue addressed in the June 2015 amendment to the law.

- **Currency risk.** The law makes FiTs payable in US dollars, which encourages foreign investors. However, this effectively passes the currency-exchange risk onto the government. When the Mongolian currency depreciates, as it has done dramatically against the US dollar in recent years, the government comes under financial pressure.

Delays in activating the Renewable Energy Fund have added to the strain. The fund was created by the Renewable Energy Law to cover incremental costs associated with renewable power generation. Without this mechanism, the government continues to bear the brunt of fiscal pressures, making

[1] According to calculations by Mongolia's National Renewable Energy Centre (NREC) based on data from the US National Renewable Energy Laboratory (NREL)
[2] Consisting of excellent wind resources (2 550 TWh), moderate wind resources (8 123 TWh) and solar resources (4 774 TWh)
[3] Estimated at 12 100 TWh by the National Renewable Energy Centre of China

Solar PV array in rural Mongolia
Photo: Enebish, N.

investors wary about future engagement. The recent amendment includes a "support tariff" to address this issue; how effectively remains to be seen.

The feasibility of applying a renewable energy quota system in Mongolia should be studied. Such a system would create a market that enables the development of renewables, thereby helping to meet targets. Quotas can be cost-effective as a policy scheme, as they maintain a market-oriented approach. More importantly, they can incentivise coal-fired power plants to embrace renewable generators as an added revenue source. Domestic renewable energy development, in turn, will help prepare the country for a regional electricity market. Renewable electricity certificates could provide an added revenue stream when a cross-border power grid is established with China.

If funds from the centralised government budget are needed to maintain support policies, the government can explore a variety of options for long-term soft loans and technical assistance. For instance, a public-private partnership could attract grants and loans from international financial institutions and donor countries, along with private financing. The Renewable Energy Fund could be augmented by air pollution taxes, mining revenues, fossil-fuel taxes, or a portion of electricity tariffs.

Grid assessment for the integration of variable renewables

Following two years of operation of the first wind farm in the Central Energy System, grid operators have gained some experience in dealing with variable renewable sources and have also encountered some challenges. However, scaling up deployment for the future would require a comprehensive assessment of the power grid infrastructure, from which a strategy of how to deal with the increase of variable renewable sources when flexibility is constrained, can be developed.

The focus of the recommended study can be extended from centralised wind farms to distributed generation, including small-scale roof-top and utility-scale solar photovoltaic (PV) farms in place of substations. For this, power flow and stability analyses are needed for both engineering and energy planning purposes to provide a better understanding of how connecting variable renewable sources affects the grid in an aggregative manner. The analytical results would help grid operators predict the grid response to solar and wind generation inputs at various points and different penetration levels, and also help energy system planners develop an integrated plan for adding variable renewable-based generation capacity and grid expansion or enhancement. The study would be also useful for grid integration of variable renewable and assist grid operators, namely the NDC in Mongolia's case, in identifying the right controlling programs and operational skills to better match renewable electricity produced from variable renewable energy sources with demand load and dispatchable generators.

Institutional and human capacity

To scale up renewables in Mongolia, officials in governmental energy authorities, practitioners, researchers, technical advisors and university graduates must be properly equipped. All of them will need updated knowledge and information on renewable energy development, including the latest technological advances, cost reduction, innovative policy and regulatory schemes, and emerging challenges in project implementation.

In recent years, the need has grown to enhance the technical and co-ordination capacities of energy sector institutions in Mongolia, particularly to address the emerging issues arising from renewable energy integration. This much-needed capacity enhancement would help the MoE, along with other governmental authorities, grasp the root causes of the challenges in renewable energy development. This, in turn, would help prevent future problems through enhanced strategic energy planning.

The capacity of the National Renewable Energy Center (NREC) needs to be reviewed against this backdrop. Following such a review, specific capacity enhancement programmes could help NREC work more closely with the MoE and provide advisory services to the government in co-operation with other entities in the energy sector.

The National Dispatch Center (NDC), Mongolia's grid operator, also needs capacity enhancement for variable renewables to be prioritised over coal-based electricity. At present, power from variable renewables faces grid-access challenges. For both technical and economic reasons, such power is curtailed whenever loads are low. Thermal plant operators strive to avoid dialling their steam generators back too far, as such situations result in operational inefficiency and financial losses. As newer, more efficient combined heat and power (CHP) plants gradually come on line, they can provide conventional base-load power with the required adjustments for the impact of variable renewables.

The NDC will have to accommodate the growth of variable renewable sources. To do so, it needs the operational capacity to manage large-scale variable renewables on the grid. Further ahead, the creation of a capacity market or a regulating/ancillary service could compensate for economic losses when CHPs operate under reduced loads. Developing Cross-border Grid Infrastructure to Export Renewable Electricity Amid rising demand for cleaner energy sources in China and other countries in the northern Asian region, Mongolia sees the opportunity to become a regional renewable energy exporter. The notion of exporting renewable power from the Gobi Desert through the Asian Super Grid (ASG)

Solar home systems at a nomadic encampment
Photo: Shutterstock

is attracting increasing interest from investors and developers. The grid would connect Mongolia, Russia, China, the Republic of Korea (South Korea) and Japan.

The size of the Gobi Desert and high upfront costs entail considerable technical and political and socio-economic challenges beyond the ASG's preliminary phase. All implications must be carefully studied for the potential of the super grid to be realised. This would involve detailed resource assessments, as well as studies to determine optimal land uses, grid conditions and locations for dispatch centres. A feasibility study involving all five ASG nations is recommended to help their governments understand the costs and long-term benefits of the plan. The hope is that governments would then more willingly collaborate in regional super-grid development.

More specifically, a consortium of the five countries, with support from each national government, should be formed to conduct a comprehensive feasibility study. Such a study should also involve regional and international organisations. An international platform could provide greater legal certainty for participating countries, investors and other stakeholders; allow for better alignment of national renewable energy targets; create and maintain harmonised trade and transit rules for electricity; and improve the overall regional investment climate.

To mitigate investment risks, the process could start with smaller projects, which could be aligned around the Gobitec/ASG vision after the comprehensive feasibility study. Such projects could start at the national level and later evolve into bilateral and multilateral projects. In parallel, ministerial meetings among ASG countries would enable consensus-building and harmonisation on technology standards and regulations.

Looking ahead

The vision of developing Mongolia into a regional clean energy exporter is plausible, albeit challenging. The present study, based on the country's RRA consultations, indicates that the renewable energy targets set by the government are attainable. However, issues pertaining to the accelerated deployment of renewables must be considered from a systematic, regional perspective. The proposed regional super grid offers a promising market for Mongolia's potentially large renewable energy output.

INTRODUCTION

Off-grid solar PV
Photo: Sukhbaatar, Ts.

01

1.1 Country Background

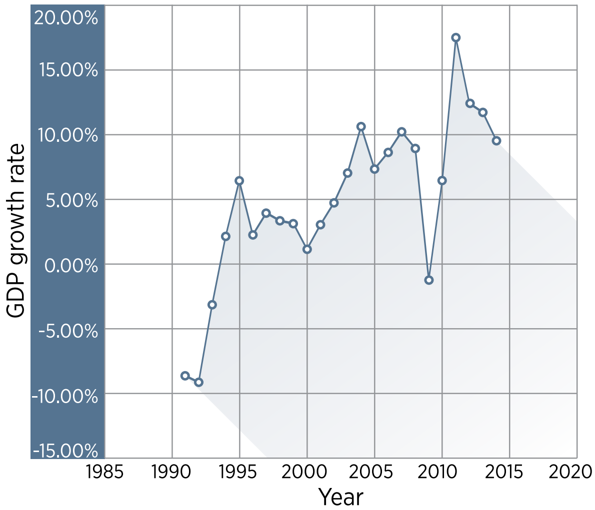
Mongolia is a vast, resource-rich country with a lower-middle-income economy.[4] It is a landlocked country in east and central Asia, situated between China and Russia. The total land area is 1 566 500 km^2, equivalent to one tenth of the land area of the United States of America, although the population is as small as 3 million (National Statistical Office (NSO), 2015). This makes Mongolia one of the most sparsely populated nations in the world.

The past decade and a half has seen steady economic growth in Mongolia, with a remarkable surge in more recent years. Gross domestic product (GDP) growth peaked at 17.5% in 2011, as shown in Figure 1, attributable largely to production at the Oyu Tolgoi copper and gold mine. The year 2014 saw a slowdown in economic growth to 7.8%, from 12.8% the previous year, and a sharp 74% dip in foreign direct investment, while the inflation rate surged to 13% (World Bank, n.d., "Mongolia"). Regardless of these fluctuations, Mongolia's mining sector remains the largest contributor to economic growth. In 2014, mining contributed nearly 35% of GDP and 80% of the total exports[5] of mineral products.

The downward trend was expected to continue through 2015 and into 2016, as estimated by the Asian Development Bank (ADB, 2015) in Asian Development Outlook 2015. The first quarter of 2015 saw only a 4.4% year-to-year growth, according to the World Bank's Mongolia Monthly Economic Brief (Lee, Shiilegmaa, Batsuuri, 2015). The second phase of the Oyu Tolgoi copper and gold mining project, worth USD 5.4 billion, began moving forward following negotiations in May 2015 that brought two years of deadlock to an end. The economy, consequently, was expected to benefit from increased monetary flow from foreign investors.

[4] According to the World Bank categorisation.
[5] Based on the data from Mongolia Research Hub of the Centre for Social Responsibility in Mining.

Figure 1. Mongolia's annual economic growth rate, 1991-2014



Source: The World Bank.
*2014 data was estimated by the World Bank and IMF.

This is also in alignment with the government's development strategy, *i.e.* increasing living standards in line with higher fiscal revenues derived from the export sales of coal, copper, gold, molybdenum, fluorspar and zinc.

However, to further capitalise on its mineral endowments, the country must invest heavily in its energy infrastructure in the coming years to ensure that it has the power for its mineral production activities and to meet growing demands for energy services from other sectors. This includes the residential sector, which is increasing its share of energy consumption due to the growing population and increased use of electricity per capita.

The sheer pace of economic development in the country has led to significant environmental challenges, particularly in large cities and mining regions, due in large part to combustion of coal. Coal is abundant in Mongolia and accounts for more than 90% of the total primary energy supply.

The major urban centres are the capital Ulaanbaatar, and the industrial cities of Erdenet and Darkhan. The population of Ulaanbaatar has doubled since the beginning of the 1990s to around 1 250 000 citizens (NSO, Mongolia). Whilst the city centre boasts office towers, hotels and low-rise apartment buildings, around 60% (World Bank, 2009) of the inhabitants of Ulaanbaatar live in more rural ger[6] districts surrounding the city, without access to centralised heating and basic services. Winter air pollution has become a notorious problem in Ulaanbaatar. Three major sources of pollution come from the peri-urban ger residents who use coal-fired stoves for heating, the coal-fuelled combined heat and power (CHP) plants located within the city running at full production, and the growing number of vehicles on the roads.

The concerns over degradation of the local environmental quality are growing in Mongolia. The World Health Organization (WHO) listed Ulaanbaatar as one of the five most polluted cities in the world. Fine particulates in the air have reached as high as 750 micrograms per cubic metre (ųg/m^3) in the winter season while the annual average ranges from 136 to 141 ųg/m^3, which is significantly higher than the WHO guideline level of 10 ųg/m^3 (Guttikunda, et al., 2013). These air pollution levels are estimated to cause human health damage corresponding to 18.8% of the GDP in Ulaanbaatar and 8.8% in Mongolia in 2008, according to a World Bank report (2011). To address the local air pollution issue, the Law Decreasing the Capital City Air Pollution was drafted by the president of Mongolia, and endorsed by parliament. This was followed by the establishment of the National Committee on Decreasing the Capital City Air Pollution, which had operated directly under the Prime Minister's Office to enforce the law until early 2015, when it was affected by government budgetary cuts.

Globally, the increased use of coal was identified as one of the main contributors to the rapid increase in greenhouse gases (GHG) emissions, according to a recent report from the International Panel on Climate Change (IPCC). The global scientific community has strongly advised policy makers to shift from fossil fuels to renewable-based energy supply in order to keep global temperature rises below 2°C – a level deemed safe for global climate. The IPCC report called for large-scale transition in energy systems towards "decarbonisation".

In response to this reality, Mongolia has realised that reliance on coal for energy over the coming decades is less optimal, particularly given the global call for actions to cut GHG emissions. The 2014 Asia-Pacific Economic Co-operation (APEC) Conference saw the US and China, the two biggest emitters of

[6] A *ger* is a traditional felt tent.

carbon pollution in the world, stake out a joint plan to curb their carbon emissions, signalling a change of direction in global climate talks. Given the significant role fossil fuels play in Mongolia's current energy mix, the country has an urgent need to diversify its fuel portfolio by increasing its share of renewable sources, as presented in the Intended Nationally Determined Contribution (INDC) that Mongolia submitted to the UN Framework Convention on Climate Change (UNFCCC) on 24 September 2015.

Already, the adverse impacts of changing global climatic patterns have been felt across Mongolia. Due largely to its fragile ecological systems, Mongolia is actually very sensitive to the climate change. One third of the population still relies on traditional economic sectors such as agriculture and pastoral animal husbandry and follows a nomadic way of life. The nomadic herder communities are vulnerable to the extreme weathers that often result in economic loss (MENT, 2009). One case in point is the severe 2009-2010 winter loss of 9.7 million cattle, or 22% of total livestock in Mongolia, which in turn doubled the price of meat while dragging GDP growth in 2009 down to only 1.6% (Michigan State University (2013).

Mongolia is at a crossroads on its energy journey. The Green Growth Strategy calls for balancing short-term economic growth gain against long-term green development goals. In 2012, the Ministry of Environment and Green Development (MEGD) was established as a core ministry under the new government regime, making Mongolia one of the first nations to set up such a forward-looking ministerial agency. The MEGD and the Ministry of Energy (MoE) play a key a role in shaping the green development strategy for Mongolia. In 2014, the Green Development Policy was approved by the 43rd resolution of the Parliament of Mongolia.

Thus far Mongolia has strived to adopt renewable energy technologies in harmony with local needs. More than 100 000 nomadic herders today use small solar photovoltaic (PV) systems to power their satellite communications as they graze their animals during the summer. Small hydropower schemes are also in operation throughout the country. In 2013, the first 52 megawatt (MW) wind farm commenced operation, demonstrating that the mountain ridges in Mongolia can yield utility-scale wind power. There is further potential to develop large hydropower schemes, and enormous potential for solar and wind power development. The President of Mongolia, Mr. Tsakhia Elbegdorj, has set up an initiative, known as Gobitec, to research how the country's solar and wind energy potential in the sparsely populated Gobi Desert region can be exploited. The president envisions the country's development into a renewable energy exporter to northern Asia through the Asian Super Grid (ASG), thus turning the country's abundant resources into assets to fuel its economic growth. Renewables currently contribute only a 2.2% share of total electricity consumption, while their installed capacity accounts for 7% of national power generation. Discussions are underway on how to effectively harness the country's huge renewable energy potential.

How much renewables contribute to Mongolia's efforts to 'de-carbonise' its future energy mix depends upon several key factors: resources; the costs and applicability of renewable energy technologies; grid infrastructure; legislative and policy frameworks; and regional energy cooperation. Against this backdrop, the MoE of Mongolia, in collaboration with the International Renewable Energy Agency (IRENA), has launched a project aimed at conduct a comprehensive analysis of the presence, or lack thereof, of enabling conditions for the development of renewables in Mongolia. To achieve this goal, a Renewables Readiness Assessment (RRA) has been undertaken in accordance with a methodology developed by IRENA. The key findings from this study have shown the extent to which renewable sources can be scaled up domestically as well as at a regional level.

1.2 Renewables Readiness Assessment (RRA)

IRENA's RRA is designed to define a detailed list of criteria considered necessary for the on-going operation of existing renewable energy facilities and for further renewable energy development. Applying this framework to individual countries provides a comprehensive analysis of the presence or absence of enabling conditions for the development of renewables. Crucially, this analysis needs to take into account how the renewables policy of the country contributes to its national policy objectives.

The RRA comprises a process and methodology that includes completing a set of templates and a final report. It is also designed to be conducted by national governments, thereby allowing them to obtain a comprehensive overview of the conditions for renewable energy from their own national perspective. Under the RRA, all processes and documentation are led by the country and derive inputs from discussions with stakeholders facilitated by the country focal point, with the assistance of IRENA and other development partners.

The RRA facilitates a co-ordinated approach and the setting of priorities that can facilitate discussions with bilateral and multilateral co-operation agencies, financial institutions and the private sector regarding the implementation of actions and initiatives emerging from the RRA. IRENA can also facilitate implementation of the follow-up actions, where necessary, after the specific request from the country or regional entity.

An overall objective of this project is to highlight the key results that can help in formulating Mongolia's renewable energy development action plan, mobilising all resources necessary to carry out the actions identified and flagging the potential issues that need to be further addressed.

More specifically, the RRA aims to:

- Identify the critical and emerging issues associated with, and arising from, the development of Mongolia's energy sector in general and the utilisation of renewable energy resources in particular.

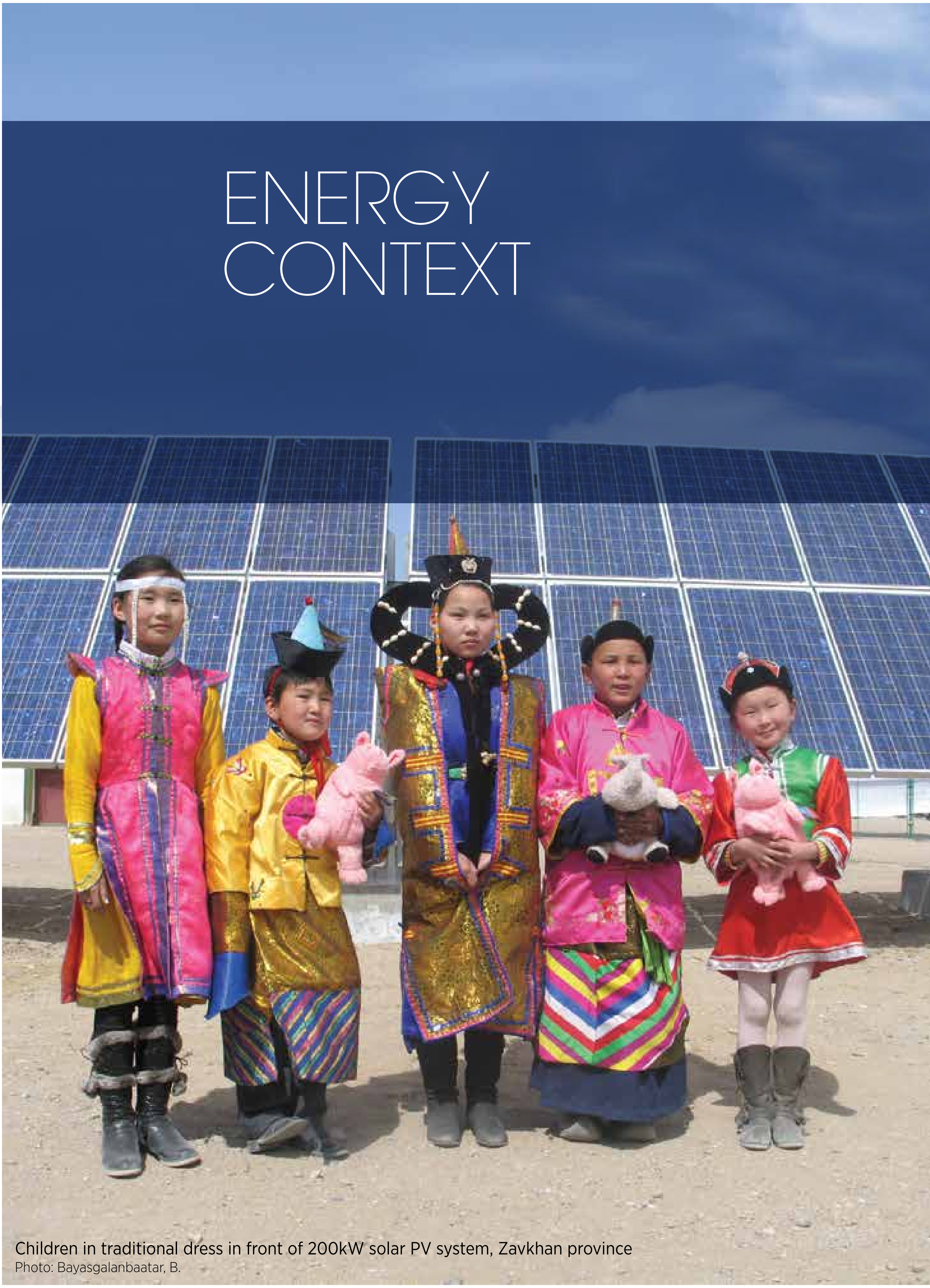
- Put forth a portfolio of articulated actionable initiatives that can capitalise on the opportunities revealed through the examination of Mongolia's energy sector and the extensive discussions with multiple stakeholders in terms of how to turn potential of resources into energy sources.

- Outline the follow-up activities to ensure the actions identified are actionable in the near- and mid-term timeframe.

Lastly, this report serves to document the process of applying the RRA methodology to Mongolia. It includes reviewing the energy sector in relation to the development of renewable energy sources in the country, describing how the RRA workshop in Mongolia contributes to the development of an action plan to scale up the deployment of renewable energy sources in Mongolia, and articulating the actions identified into a structured portfolio. This not only ensures synergies, but more significantly facilitates harmonisation among the stakeholders involved to help deliver Mongolia's goals on green growth development.

Wind turbine in Gobi Desert, southern Mongolia
Photo: Shutterstock

ENERGY CONTEXT



Children in traditional dress in front of 200kW solar PV system, Zavkhan province
Photo: Bayasgalanbaatar, B.

02

Mongolia is endowed with abundant natural energy resources, mostly in the form of coal and renewables such as wind, solar and hydropower. In the past, the country has heavily relied on coal for power and heat production. With the new strategic vision of establishing sustainable development opportunities, Mongolia has formulated a green development policy chartering the path to wean the country off coal.

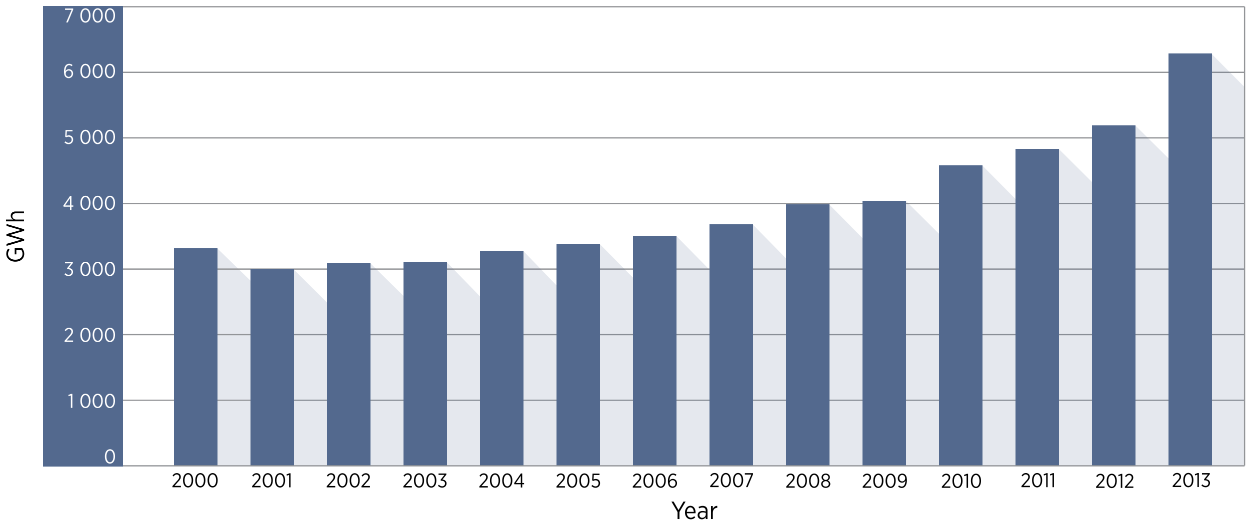
In recent years, Mongolia's energy industry has embraced greater shares of renewable sources. The Salkhit wind farm (52 MW) has been in operation since 2013 and another wind farm project in Sainshand, which also aims to supply 52 MW of electricity generation capacity will be expected to start in 2016 and commissioned in the middle of 2017. In addition, a feasibility and environmental impact assessment for the Egiin Hydropower Power Plant, with 315 MW capacity, has been completed and will commence construction in 2016. These projects present only part of the government efforts to reach Mongolia's targets of increasing renewable power-generation capacity to 20% of installed capacity by 2023 and to 30% by 2030.

2.1 Energy Situation

Given large coal reserves, estimated at 173 billion tonnes, Mongolia's primary source for energy has been coal, with the rest made up by hydropower, oil, biomass and imported electricity from Russia.

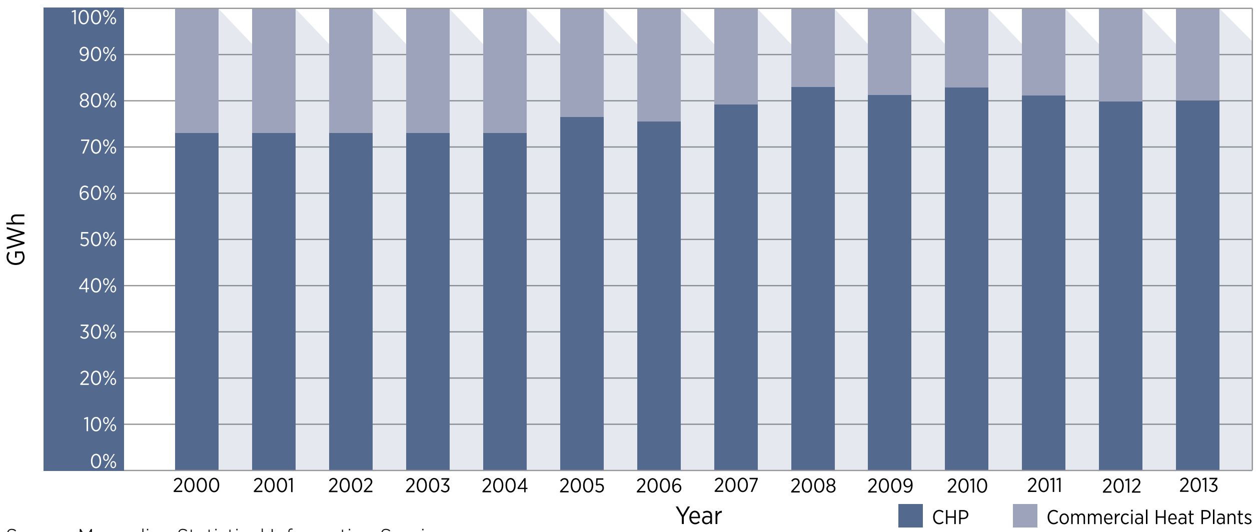
Electricity production rose between 2000 and 2013, as indicated in Figure 2, due largely to the rapid growth of demand. In addition, electricity imports from Russia increased dramatically to 1 195.5 gigawatt-hours (GWh) in 2013, compared to only 366 GWh recorded in 2012. This reflects importance of electricity imports for power system stabilisation, which prompted Mongolia to use Russian power supply despite high import costs.

Figure 2. Mongolian electricity production, 2000-2013



Source: Mongolian Statistical Information Service (n.d.)

Figure 3. Mongolian heat production, 2000-2013

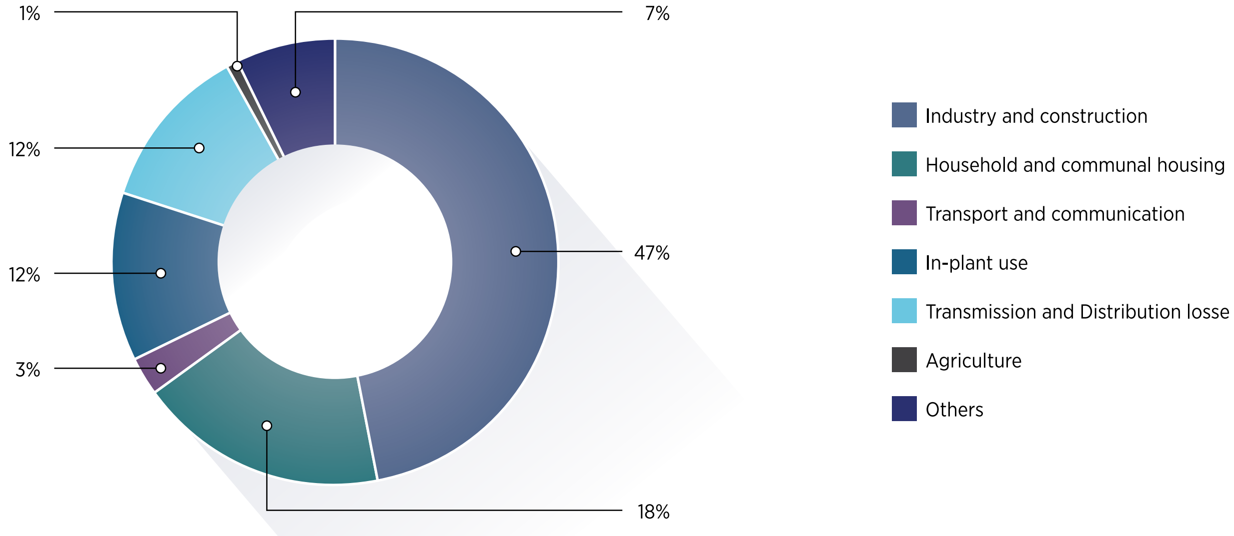


Source: Mongolian Statistical Information Service

Heat supply over the long and cold winter period is essential for every Mongolian. Despite this fact, the country's heating infrastructure is out of date and there is huge room for efficiency improvement. From 2000-2013, heating demand was growing and was being met by two sources, *i.e.* CHP systems and commercial heat plants. Both are fuelled by coal and have their own advantages and disadvantages. The discussion around which pathway Mongolia should take for its future heat production has been on-going.In terms of electricity consumption, as shown in Figure 4 below, the sector breakdown of energy consumption indicates that industry is the biggest consumer of electricity in Mongolia, followed by household users. The high level of industrial energy consumption is due largely to the Erdenet and Darkhan smelters and mining activities. Additionally, since 2010, consumption of imported oil, used mainly by the transport sector, has been increasing commensurate to the growing number of vehicles being used in Mongolia.

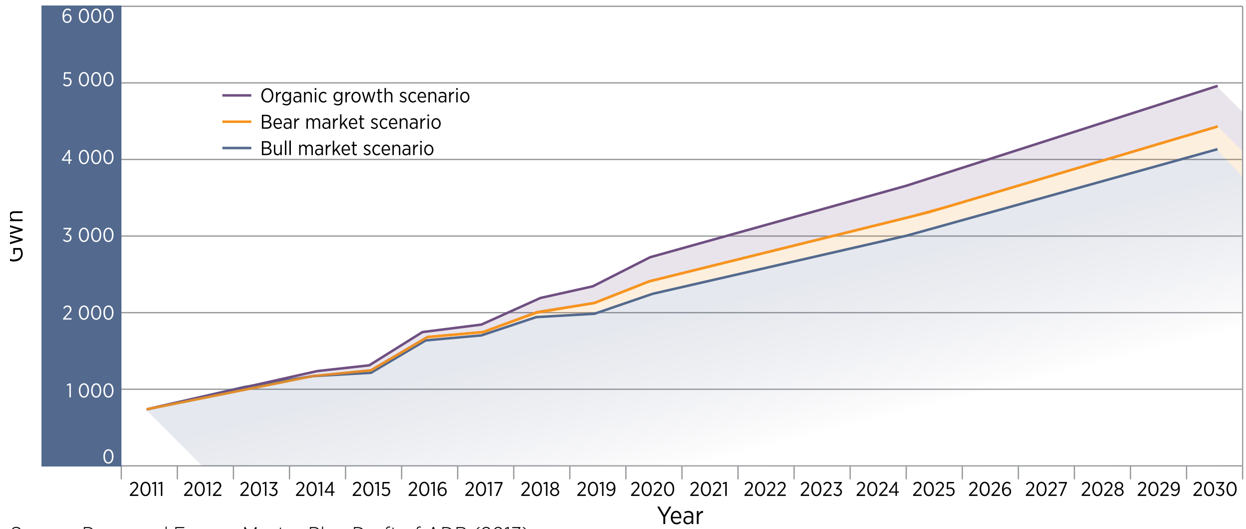
Future power demand is expected to increase despite the less aggressive growth rates expected in the years to come. Mining sector development is expected to remain the driving force for a future upsurge in energy demand. The Government of Mongolia estimates that 500-600 MW will be added to existing demand by 2020, corresponding to an average annual growth rate of 3.5%, as illustrated in Figure 5. This is largely driven by: a) the open-cast operations of the Oyu Tolgoi copper and gold mine, which was commissioned in 2012 and is

Figure 4. Electricity consumption by sector



Source: Ministry of Energy, 2014

Figure 5. Future power demand in Mongolia



Source: Proposed Energy Master Plan Draft of ADB (2013)

due undergo capacity expansion that will result in increased electricity demand to 300 MW and above as early as 2017,[7] b) the operation of underground mining at the Tavan Tolgoi coal mine, which will see demand rising to 300 MW by 2018.

The main power generation projects being built for the Central Energy System and South Gobi are as follows (World Bank 2008):

- **Thermal Power Plant #5 (TPP#5), Ulaanbaatar:** A CHP plant to be built in 300 MW units.
- **Tavan Tolgoi Thermal Power Plant:** An air-cooled mine-mouth sub-critical plant to be built in 300 MW units and fuelled from the Tavan Tolgoi coal mine.
- **Oyu Tolgoi Thermal Power Plant:** An air-cooled sub-critical plant to be built in 150 MW units and fuelled from the Tavan Tolgoi coal mine.

Other projects currently in the planning stage in the same areas include Shivee Ovoo Thermal Power Plant (TTP) and the Baganuur Integrated

[7] Development of the Oyu Tolgoi mine, expected to become the second largest copper-producing mine in the world, has already been greatly hampered by a lack of electricity. In October, Rio Tinto was forced to look to China to set up a power agreement to serve the Oyu Tolgoi mine for the first half of 2013, as Mongolian installed capacity was not sufficient and the power grid was not yet extended to the area. The mine's peak demand is expected to exceed 300 MW as early as 2017.

Figure 6. Energy Systems of Mongolia

Source: Mongolian Ministry of Energy

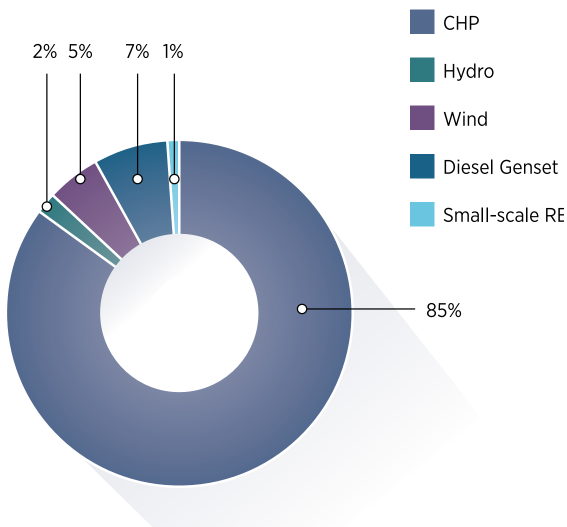
Gasification Combined Cycle (IGCC) plant. These are primarily export-oriented projects. Besides such coal-powered thermal power plants, several renewable energy projects now in planning, including the Shuren, Egiin and Orkhon hydropower plants (HPPs) as well as new wind and solar farms.

2.2 Electric Power System

The Mongolian electric power system consists of the four independently operating electricity grids including the Central Energy System, which is the main grid providing more than 90% of the national electricity supply, the Eastern Energy System, the Western Energy System and the Altai-Uliastai Energy System, as shown in Figure 6, in addition to an isolated CHP system in the south Gobi region. Given the country's large geographic area and small population, the grids can cover only the major load centres such as big cities and industrial areas. Currently, 329 Mongolian soum (districts) and almost 326 settlements are connected to the grid, contributing to the 98% electricity access rate, while five soum are supplied through renewable energy sources.

As of June 2015, the total installed capacity of Mongolia is estimated at 1 082 MW according to the Energy Sector Development Policy 2015-2030. The breakdown is shown in Figure 7. The majority of Mongolian electricity generating capacity comes from coal-fired thermal power plants, accounting for 85% of the total. Most of these plants were built from 1960 to 1980 and would likely be retired in the coming years. The Energy Regulatory Commission has granted licences for construction of facilities to produce more than 1500 MW, including five wind farms with total installed capacity of 502.4 MW. In late 2014, a concession agreement for a new plant, CHP5 (450 MW), was signed. New electricity generation initiatives have witnessed a departure from the older state-owned paradigm, with private sector ownership welcomed, as in the case of the Salkhit Wind Farm.

Figure 7. Installed electricity generating capacity by source



Source: Ministry of Energy, 2015

In 2014, the peak load was 960 MW, accounting for 93% of the national total installed capacity. The maximum available capacity of importing electricity from Russia is about 250 MW. In view of retirements, if the demand growth outpaces the new capacity addition, Mongolia will be facing a serious shortage of electric power in coming years.

Table 1. Generating facilities in the Central Energy System

Generator	Installed Capacity (MW)	Available Capacity (MW)	Year of Commission	Energy Conversion Efficiency (%)
CHP2	22	18	1961	20.4
CHP3	190*	155	1968	38
CHP4	703**	575	1983	40.6
Darkhan CHP	48	39	1965	29
Erdenet CHP	28.8	21	1987	41.5
Ukhaa Khudag Power Plant	18	18	2011	28
Salkhit Wind Farm	52	52	2013	27.9

* A 50 MW upgrade was made in June 2014.
** A 120 MW extension was made in December 2014.
Source: Mongolian Ministry of Energy

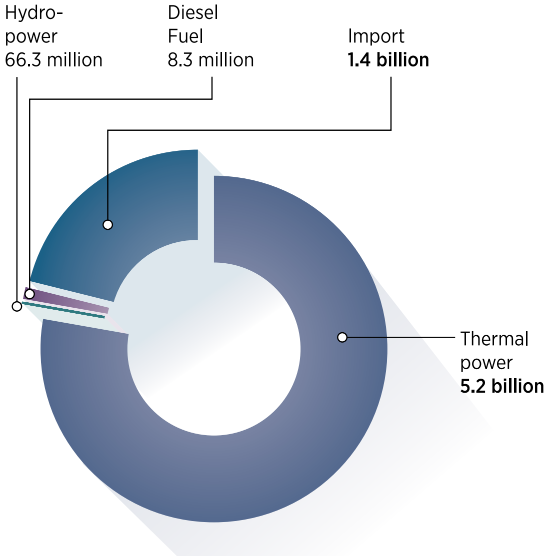
According to the Energy Regulatory Commission of Mongolia, electricity consumption in 2013 witnessed a significant increase by nearly 20% amounting to 6 323 GWh, or in absolute terms, an increment of 1 055 GWh from the 2012 level of 5 268 GWh, including 308 GWh of imported electricity. For the same year, CHPs fuelled by coal contributed to nearly 80% of the total electricity supply while about 18% was imported from Russia and China, with diesel, hydro and wind electricity making up the remaining 2% of the total.

In 2014, 6 788.7 GWh of electricity was produced, according to the MoE. The breakdown, shown in Figure 8, reflects the decline in share of thermal power and the continued growth in imported electricity to meet the widened supply-demand gap. This was largely due to behind-schedule installations of new power generating capacity, leading to diminishing reserve capacity to supply the increasing peak load demand.

Of the four independent power systems, the Central Energy System is the largest, covering consumers in 14 of the 21 first-level administrative subdivisions known as aimag in the Khangai, Central and South regions. This system represents annual electric energy demand of 960 MW and annual electricity consumption of 4 300 GWh, supplied largely by seven power plants, as shown in Table 1. The Central Energy System is connected to the Russian power grid system through a 220 kilovolt (kV) overhead transmission line.

The Western Energy System serves the consumers in Uvs, Bayan-Ulgii and Khovd Aimags, with annual electricity consumption of 108 GWh and peak demand of 30 MW in 2014, recording a dramatic increase from 2013 due largely to the growing use of floor heating.

Figure 8. Breakdown of Mongolia's power supply in 2014 (kWh)



Based on: Ministry of Energy, 2015

The Western Energy System has only one generating source, *i.e.* the 12 MW Durgun Hydro Power Plant, which was put into operation in 2008. The majority of electricity, on average 70%, is imported from the Russian Krasnoyarsk energy system at Chadan Substation through the 110 kV[8] transmission line, importing electricity operating at the capacity of approximately 25 MW.

The Eastern Energy System covers the area of Dornod, Khentii and Sukhbaatar aimags, with annual electricity consumption of 112 GWh and peak demand of 27 MW. The Dornod Thermal Power Plant is the main power source of the eastern energy system, with a capacity of 36 MW. The Eastern Energy System has a 190 kilometre (km) long 110 kV single circuit line that connects the 110 kV substations at the two aimag centres of Choibalsan and Baruun Urt.

The Altai-Uliastai Energy System provides electricity to Zavkhan and Gobi-Altai aimags with annual electricity consumption of 33 million kWh and peak demand of 16 MW from 11 MW Taishir Hydro Power Plant and diesel power plants at Uliastai and Esunbulag.

Average annual per capita electricity consumption reached 2 263 KWh in 2014,[9] representing an increase of 18% from the 2013 level – approaching the global average of 2 770 kWh. However around one third of the total energy consumption in Mongolia can be attributed to the Erdenet and Darkhan smelters and other energy intensive industries. About 60% of Mongolian total households are connected to one of the five grids, representing 92% of the total grid-connected utility customers. If taking into account the local/mini-grids, access to electricity is 98%.[10] This suggests there is much room to grow in electricity demand in Mongolia's domestic sector.

As far as transmission is concerned, there are three independent grids in Mongolia. Transmission voltages are 220 kV (in the Central Energy System and South Gobi only) and 110 kV, while the principal medium distribution voltage is 35 kV, which is further stepped down to 10 kV or 6 kV. Electricity is also imported from China to supply the southern border towns and the Oyu Tolgoi mine.

2.3 Rural Electrification

Mongolia's high electricity access for such large, sparsely populated area is largely attributable to the efforts of the government and the World Bank over the past decade and a half. A joint programme has provided portable solar home systems (SHS) to rural families, most of whom still follow the nomadic lifestyle, as seen in Box 1. Given the limited capacity that SHS can provide, it can only meet the very basic energy demand such as lighting, radio and TV. There may thus be a need to upgrade the existing SHS, which can be operated on a commercial basis, due to the supply chain established throughout the rural electrification programme, and the dramatic reduction in the cost of solar PV systems over the past years.

Mini-grids powered by purely solar or wind, or as hybrid systems, are also used in rural or remote areas. Table 4 presents a list of detailed off-grid mini-grids.

8 The designed capacity is 220 kV, with even higher transmission capacity. The facility currently operates below under its full capacity.
9 According to the Mongolian Energy Engineers' Association.
10 According to the latest data from the Mongolian Ministry of Energy.


Solar-wind telecom system, Gobi-Altai province
Photo: Bayasgalanbaatar, B.

Box 1:

Rural Electrification Programme

Mongolia is rapidly urbanising, leading to the development of settlement centres that are mostly connected to the grid network. Out of the estimated population of 3 million, around 500 000 to 750 000 people still engage in the nomadic lifestyle for part of the year.

At the beginning of the century, the Government of Mongolia launched the "100 000 Solar Ger Program" with the aim of providing rural families, mostly nomadic households, with a set of basic mobile solar PV systems, to supply electricity for basic needs such as lighting, powering radio and TV. After years of implementation, the government encountered a shortage of funds to sustain the programme implementation. At the request of the government, the World Bank helped overcome this shortfall, allowing the programme to be continued scaled-up to benefit more rural households.

In 2006, the World Bank approved the Renewable Energy and Rural Electrification Project (REAP) whereby resources were made available to subsidise 50% of the solar PV system costs for 50 000 households. This model was endorsed by the Government of the Netherlands, with additional funding made available to support the cost buy-down scheme.

More importantly, a system for quality assurance and after-sale was set up to ensure the sustainability of the donor-funded project. This has enhanced the confidence of consumers and helped herders make an educated choice regarding the purchase, and operation and maintenance of their mobile solar PV systems. Additionally, 50 Sales and Service Centres have been established across the country, serving as hubs of information sharing, equipment provision and after-sale services including warranty. This has helped develop a network of equipment and service-providers, which is a critical step towards commercial market development in Mongolia.

This programme was regarded as being highly successful in Mongolia, demonstrating the collaborative efforts to scale up rural electrification using small-scale solar PV systems for rural and nomadic households. Today, the target of 100 000 households equipped with SHS has been exceeded. However, the unit capacity might need to be upgraded, given more domestic appliances are used today as a result of improved living standards.

2.4 Domestic Electricity Markets

In 2001, an electricity market was introduced in the form of a bilateral contract (single buyer) market, accompanied by a small spot settlement market and an auction market. The Central Regional Electricity Transmission Network operates as a single buyer, purchasing electricity from the five power plants in the central region and in the form of imports from Russia (International Energy Charter, 2013). The network then sells this power to the ten electricity distribution companies. Such transactions are conducted in an electricity spot market, based on differences between scheduled power generation and actual, real-time power supply. An auction market is also organised among the generators based on their offered generation tariff and the growth in electricity demand.

Annual traded electricity amounted to 3 844.4 GWh in the single buyer market in 2011, 3.9 GWh in the spot market in 2010, and 4.45 GWh in the auction market in 2011 (International Energy Charter, 2013). Market-based electricity trading has not yet succeeded, reportedly due to cash collection problems at the distribution level and revenue shortfalls experienced by the generation company. The market reverted to a single-buyer approach, which operates differently from a single-buyer market model in the strict sense of the term. The National Transmission Company (NTC) is not entitled to own the electricity produced by generation companies and was not legally responsible for paying them.

The function of the NTC was to allocate the revenue collected to the generation companies through the zero-balance account that it was managing. The system operates essentially as a vertically integrated utility, unbundled in practice into distinct business units and receive a portion of retail revenues based on a pre-approved formula administered by one unit, the NTC. FiTs for renewable electricity – maintained by the government as a form of subsidy – also operating this way until the recent amendment of the Mongolian Renewable Energy Law. Subsequently, the responsibility of managing the zero-balance account was transferred to the National Dispatching Center (Mongolia's grid operator).

Although a sound energy market should promote operating efficiencies and the provision of guidance for investment via pricing signals, the current market model does not perform in a manner to deliver these desired outcomes.

That said, CHPs are technically efficient when producing electricity at maximum heat output (cogeneration mode). In Mongolia, heat production does not take place in the summer, and so the overall efficiency of CHP-generated electricity is low. Thus, the efficiency of energy supply in Mongolia is not only a function of technology or operating practices, but also a function of climatic temperature variation throughout the year. When a CHP plant produces heat, electricity is also produced as a 'must-run' by-product, with the ratio of heat to electricity as large as two for one. This cogenerated electricity must be dispatched for the safety of the grid operation.

Another factor affecting the power market in Mongolia is the efficiency of generators. In Ulaanbaatar, Thermal Power Plant No 4 has a very large capacity compared to the other plants. When a new CHP is established in Ulaanbaatar, it will be a modern, highly efficient plant and will always be first to be dispatched. As a result, the merit order will never be in doubt and the maximum efficiency of the electricity system will be readily determined by the central dispatchers from the turbine efficiency curves of the plants.

2.5 Power Trading and Exchange

Mongolia has in recent years come to depend more and more on Russian energy imports to cover short-term contingency needs, for instance during peak demand. Two interconnectors are under operation between Mongolia and Russia. The 250 MW interconnectors are designed to provide both load following and emergency back-up functions, but in recent years, the interconnection has begun to serve peak demand as well. The electricity trade contract is negotiated every year to set the price and capacity. For example, the average price of import in 2013 was only USD 77 per MWh, however there are penalties associated with breaches of the contracted capacity. The expenditure on imported electricity has become a financial burden for Mongolia, and will increase if and when Russia raises the electricity price as a result of low electricity generation from the hydropower power plants in the Angar River with water supplied by the Baikal Lake. An example of this was the 30% imported electricity price rise recorded in 2014.

Russia has invited Mongolia to create an electricity 'pool' market that would clearly be more favourable to Russian exports and cross-border plant utilisation. Meanwhile, increased power imports from Russia have the potential to reduce Mongolia's carbon footprint if the energy is provided from Russian hydropower plants. A decision on this matter may come down to an evaluation of the financial terms of these options.

Electricity to supply Mongolia's southern border towns and the Oyu Tolgoi mine is also imported from China at prices of around USD 110 per MWh.[11] In recent years proposals have been made to export coal-fired power to China. One proposal involved a coal-fired power plant of 3 600 MW with a high-voltage direct current (HVDC) power line extending from the Shivee Ovoo coal field to Beijing. This proposal is reported to have failed due to the value added tax that is applied to power imported into China. Recently, it has been reported that the proposal is under consideration once again. At the same time, the government has been promoting the idea of exporting large-scale wind and solar energy to China.

To promote power trading between Mongolia and neighbouring countries, the ASG initiative has been proposed to connect locations of high energy demand with regions in the Gobi Desert that have tremendous solar and wind energy potential. The Gobi Desert is a suitable place for the construction of both solar and wind power plants, with 300 days of sunshine per year, high level of wind resources, low moisture and low temperatures. According to the International Energy Agency (IEA) Photovoltaic Power Systems (PVPS) Task 8 study, energy production in the Gobi Desert is more efficient than renewable energy production in other desert areas. The theoretical potential of solar energy of the Gobi Desert is enormous. According to the Task 8 study about 40% of the Gobi Desert is suitable for construction of very large-scale solar power generation projects.

According to findings by the National Renewable Energy Center (NREC) using data from the US National Renewable Energy Laboratory (NREL), Mongolia's wind energy potential amounts to at least 1.1 terawatts (TW), while solar potential is about 1.5 TW (Stackhouse and Whitlock, 2009). The country's total renewable energy of Mongolia, including wind and solar resources, could be as high as 2.6 TW. Wind energy density averages 7 MW/km^2, while solar energy density averages 66 MW/km^2. It has been suggested that a northeast Asian electricity market might develop based on economic and environmental benefits. The Gobitec concept is therefore proposed to connect locations of high energy demand with the Gobi Desert region that has large renewable energy potential. The energy produced is meant to be delivered through power corridors, including the planned ASG connecting Russia, Mongolia, China, South Korea and Japan. The regional electricity markets in Europe and the Greater Mekong sub-region provide precedent for such cross-border trade schemes.

The Gobitec project will provide economic and social benefits to the northeast Asian region. The participating countries will benefit from increased energy security and cost advantage with access to low-cost renewable-based electricity from the Gobi Desert. For Mongolia in particular, the project will diversify the local economy, create job opportunities, alleviate poverty and reduce carbon dioxide emissions and air pollution in the country.

The concept of a northeast Asian power grid has been under discussion for more than a decade. Due to high economic growth, northeast Asia has been one of the fastest growing energy markets in recent years. This trend is expected to persist in the foreseeable future, with a higher rate of energy consumption than in other parts of the world. Therefore, the energy supply infrastructure in the northeast Asian sub-region must evolve in response to emerging issues such as increasing demand, resource availability, environmental concerns, changing technologies and the need for regulatory reform, and sector restructuring.

Energy co-operation across the region is key for enhancing the security of energy supply. To maximise the benefit from regional energy co-operation, a high level political forum needs to

[11] Converted at 6.2 RMB/USD, with 0.68 RMB/kWh agreed in the signed power purchase agreement between Oyu Tolgoi mining project owner and the Chinese partner.

be established in order for all the countries to be actively engaged in developing a regional power infrastructure. Energy infrastructure integration among northeast Asian countries is intended to lead to the creation of a large market and expansion of economic potential for all participating nations and may contribute to greater political stability and security.

For this reason, the Gobitec initiative and ASG for northeast Asia proposal have been initiated. The development of the sub-regional HVDC super grid network will be one of the key components of the Gobitec initiative and super grid proposal.

In March 2013, five-partner organisations signed a Memorandum of Understanding to prepare a joint regional study entitled "Gobitec and the Asian Super Grid for Renewable Energy Sources in Northeast Asia". The organisations are:

- Energy Charter Secretariat;
- Energy Economics Institute of the Republic of Korea;
- Ministry of Energy of Mongolia;
- Japan Renewable Energy Foundation; and
- Energy Systems Institute of the Russian Federation.

2.6 Key Institutions and Stakeholders of the Energy Sector

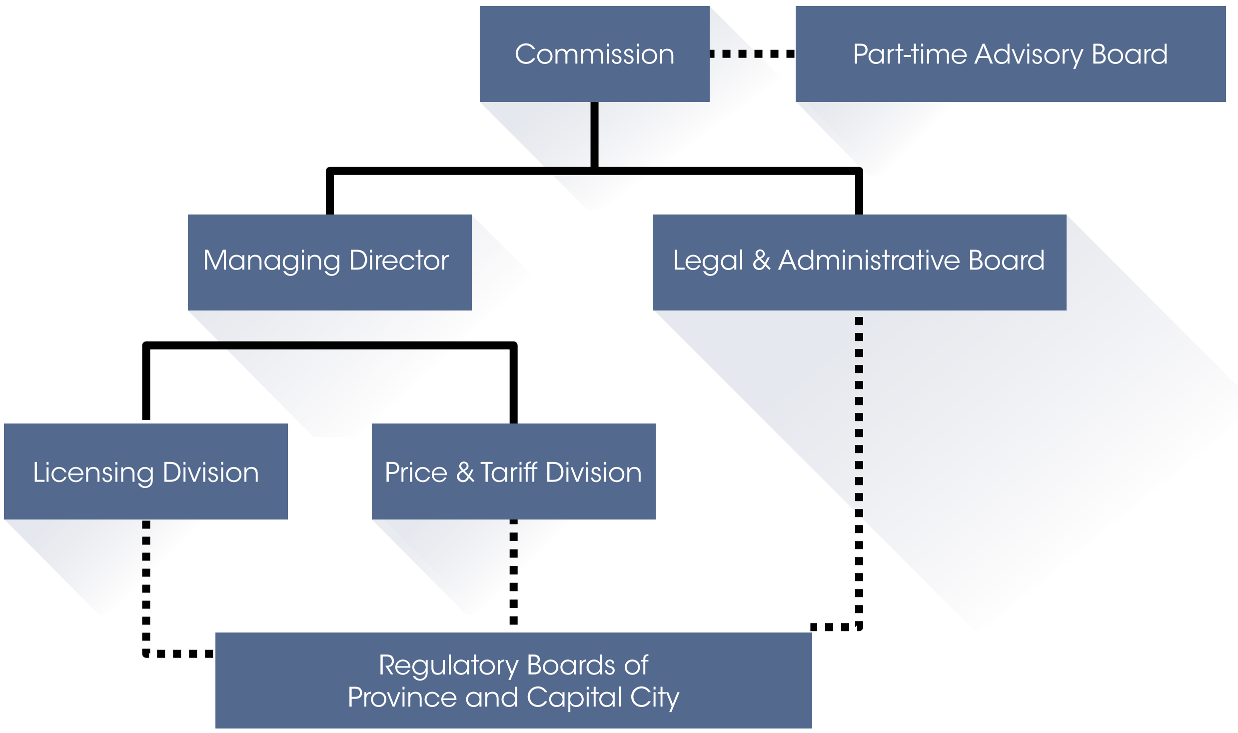
Currently, responsibilities for renewable energy development are shared across three key ministries: the MoE, the Ministry for Finance and the Ministry of Environment, Green Development and Tourism (MEGDT).[12]

The Ministry of Finance bears the responsibility for strategic planning across multiple sectors and the preparation and administration of the state budget. This includes encouraging private investment, such as public private partnerships, as a means to enhance GDP growth.

The MEGDT is responsible for environment and green development and is also engaged in international dialogue and events related to climate change by way of developing government policies and strategies on climate change; enforcing legal requirements for the protection; conservation and appropriate use of natural resources; improving

[12] In the institutional restructure of 2015, tourism was merged into the MEGD, creating the Ministry for Finance and the Ministry of Environment, Green Development and Tourism.

Figure 9. Structure of Mongolia's Energy Regulatory Commission (ERC)



Source: Annual Report, ERC 2011

Small hydropower plant, capacity 375 kW, Zavkhan province, Tosontsengel soum
Photo: Batbayar, Ts.

soil, water and forest resource management; strengthening environmental monitoring networks; conducting necessary research; disseminating scientific information about the environment to individuals and institutions; and implementing climate change projects using internal and external funding and coordinate the actions of multiple ministries, agencies and organisations.

The need to meet environmental standards for mining and utilisation of energy is addressed by the MEGDT, in accordance with the requirements of the Environmental Protection Law of Mongolia. This deals with the need to avoid adverse ecological effects on land, soil, air, water, underground resources, mineral wealth, plants, and animals.

The MoE bears the responsibilities for making energy policy, energy strategy and planning including power generation, power grid development, district heating, etc. and designing the publicly-funded programmes. The MoE sets policy for coal- and renewable-based power generation, covering the development, conservation and use of these energy resources, and import and export of coal, while also approving investment plans for electricity transmission and distribution developments. The Energy Development Centre (EDC), a government entity under MoE, is responsible for overseeing the operation of energy sector in accordance with the government's energy policy.

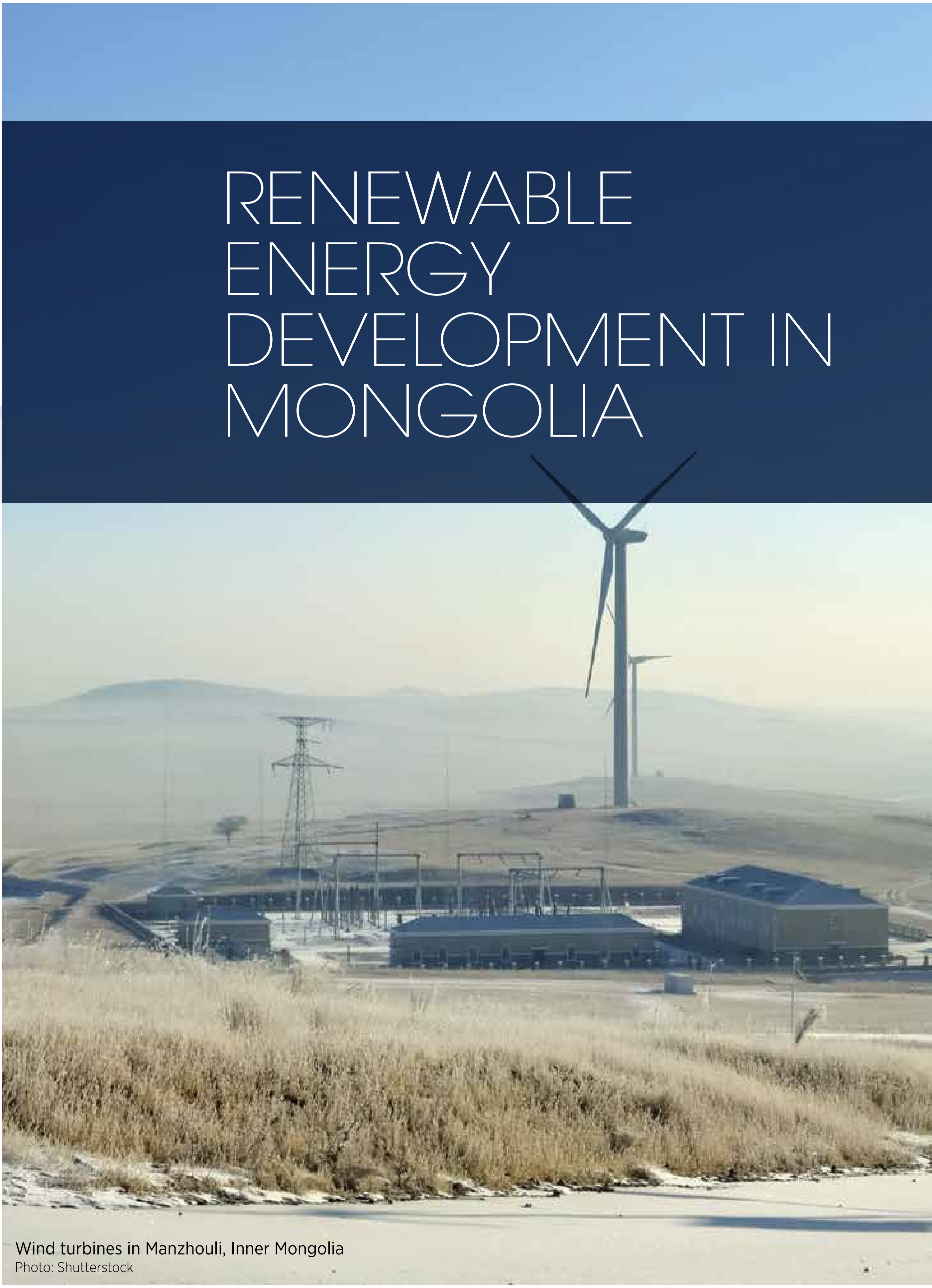
The NREC was created in 2005 under the MoE. With the restructuring of the government, the centre was changed into a state-owned self-financed entity, under the supervision of the State Property Committee. This has resulted in a significant loss of talent due to the lack of funding attributed to the removal of the budgetary support from government. The impact of that is that the centre's capacity has been weakened when it comes to assisting the MoE with the operation of renewable energy activities in accordance with the government's energy policy, in conducting studies on renewable energy resources and utilisation and in introducing new renewable energy technologies to Mongolia with research on necessary adaptation to local contexts.

The Energy Regulatory Commission (ERC) is an independent regulatory authority that was established by the 2001 Energy Law. According to the Energy Law, the ERC shall have the full power to issue operational licences to energy companies involved in the generation, transmission and distribution of electrical power; monitor compliance with license conditions; resolve disputes between agencies and customers; and review and approve the tariff of licensees. The ERC is directly accountable to the government (as represented by the cabinet).

Figure 9 shows the organisational structure of the ERC. The commission has a managing director, Legal & Administration Department, Licensing Division, and Price & Tariff Division. The Licensing Division is in charge of licensing issues, including monitoring issues relating to licensee's technical activities, monitoring of electricity markets, and dealing with rules and regulations related to technical and technological issues. The Price & Tariff Division is in charge of devising tariff methodology and rules, reviewing tariff proposals, and monitoring financial and economic aspects of the licensee.

There are two main public universities where Bachelor's, Master's, and Doctorate degrees in Renewable Energy can be obtained: the National University of Mongolia, School of Applied Physics and Engineering; and the University of Science and Technology of Mongolia, School of Power Engineering. A specialisation in renewables can also be obtained at certain private schools.

RENEWABLE ENERGY DEVELOPMENT IN MONGOLIA



Wind turbines in Manzhouli, Inner Mongolia
Photo: Shutterstock

03

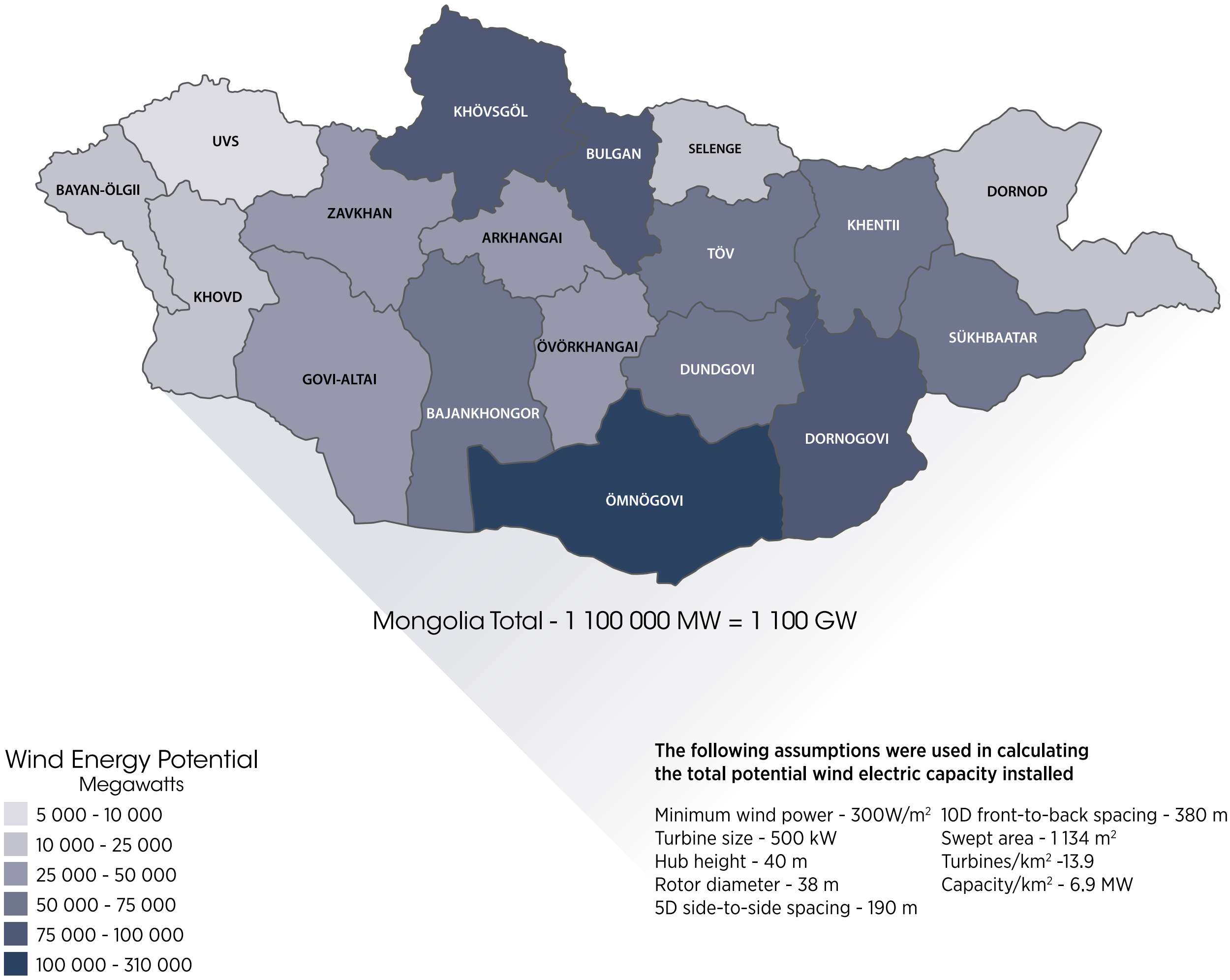
Only a negligible portion of Mongolia's enormous renewable energy potential has been exploited. To date, solar and wind deployment has been largely limited to off-grid applications, mainly for nomadic herders or isolated mini-grids. While conventional hydropower has been in use for decades, the first grid-connected wind farm, with installed generating capacity of 52 MW, started operation in July 2013.

With the growing demand for electricity domestically and regionally, coupled with dramatic cost reduction of renewable energy systems, there have emerged great opportunities for wind and solar PV applications in Mongolia. The Mongolian government has recently set targets in its Green Development Policy to increase the share of renewable energy in the total installed power generation capacity, with a view to reaching 20% by 2020[13] and 30% by 2030. The targets are deemed ambitious in relative terms, yet insignificant when measured in absolute terms, given the 2.6 TW renewable energy potential and the limited size of the domestic energy market.

However, the Mongolian government has actively explored possibilities to develop a regional integrated power market in northeast Asia, through which it can export wind and solar electricity to other countries. As estimated by the US NREL and Mongolian NREC, the combined electricity production output from wind and solar could reach as much as 15 000 TWh per year, which is enough to meet the Chinese total electricity demand in 2030 (Energy Research Institute National Development and Reform Commission, 2015).[14]

[13] It was revised to 20% by 2023 in the State Policy on Energy adopted by the parliament in June 2015.
[14] Estimated at 12 100 TWh by National Renewable Energy Centre of China.

Figure 10. Map of wind energy resource of Mongolia



Source: US National Renewable Energy Laboratory, 2001

Table 2. Breakdown of good-to-excellent wind resource potential at 30 metres high

Wind power density at 30 metres	Wind speed (metres/second)*	Total area (km²)	Installed generating capacity (MW)	Total electricity output (TWh/year)
300-400	6.4-7.1	130 665	905 500	1 975.5
400-600	7.1-8.1	27 165	188 300	511.0
600-800	8.1-8.9	2 669	18 500	60.2
800-1 000	8.9-9.6	142	1 000	3.4
Total		160 641	1 113 300	2 550.1

*Wind speeds are based on a Weibull k value of 1.8 and an elevation of 1 400 metres.
Source: US National Renewable Energy Laboratory, 2001

3.1 Renewable Energy Resources and Exploitation

Wind

The wind energy resource atlas of Mongolia produced by the NREL in 2001 is still viewed as the most authoritative estimate of wind energy potential. Mongolia has since been identified as a potential major wind power producer with good-to-excellent[15] wind resource potential at 30 metres high, estimated at more than 1.1 TW of installed generating capacity, distributed largely in the southern and eastern regions as shown in Figure 10, generating at least annual 2 550 TWh of electricity[16] – equivalent to about half of the Chinese total electricity consumption in 2014.

As shown in Table 2, if the 142 km^2 area with the highest wind potential can be fully developed, it can deliver more electric power than Mongolia's total electricity demand. Notably, the estimation was made 14 years ago, when the predominant wind turbine had 500 kW capacity and was mounted at a height of 40 metres. At present, the turbine size used for utility scale has tripled, and the typical hub height is about 100 metres. This suggests that greater capacity installed in the same areas would generate more electricity compared to the estimated 2 550 TWh from NREL in 2001.

If taking into account the moderate wind resource (at 30 metres), the above estimated total installed capacity would quadruple, while both outputs and windy areas triple. The moderate areas are generally good enough for rural electrification with small wind turbines. In some parts of the moderate areas, wind resource is good enough even for utility scale wind farms, given the categorisation is based on averaged wind speed. For instance, the country's first utility-scale wind farm – the Salkhit Wind Farm (52 MW[17]), was built in a wind-raked ridge about 72 km southwest of Ulaanbaatar, which falls in a moderate wind resource region, although this particular location area has been found to have excellent wind resource.

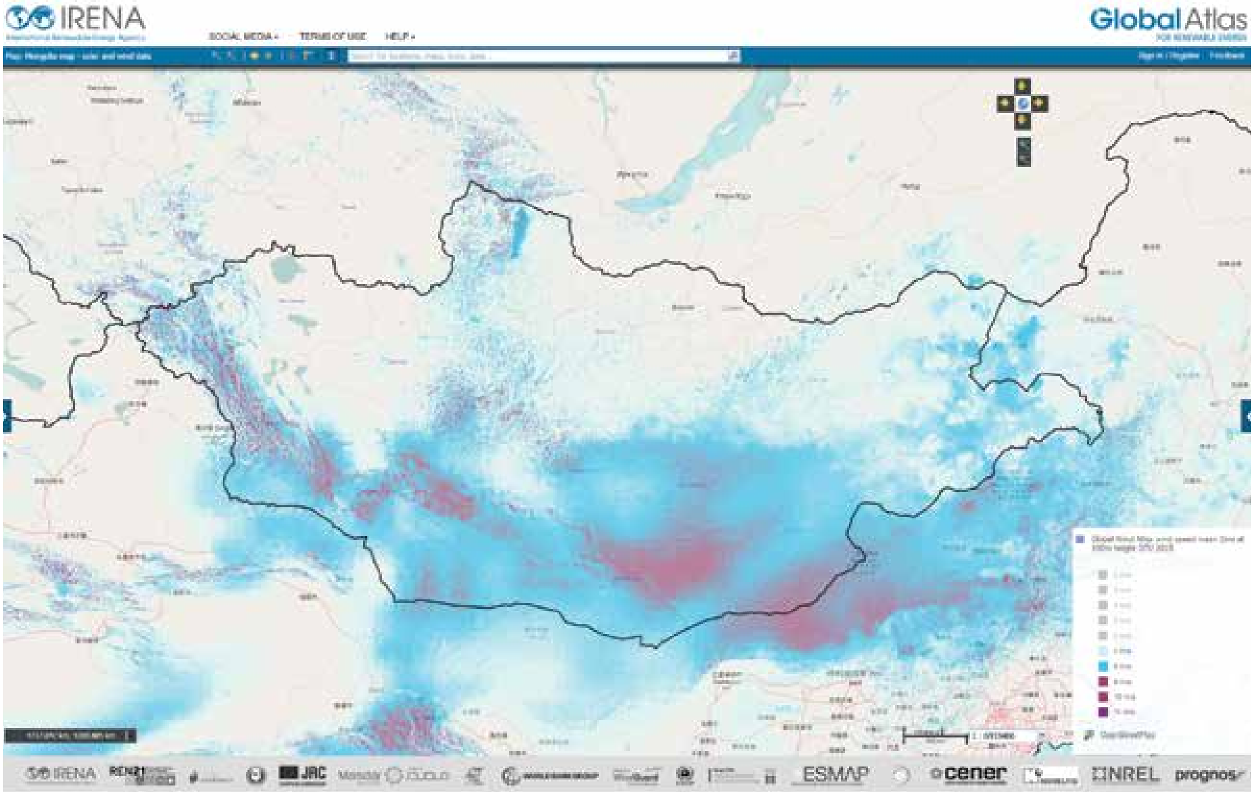
Following the commissioning of the first Power Purchase Agreement (PPA)-based Independent Power Producer (IPP)[18] model wind project financed by international investors, Mongolia has launched the construction plan for the Sainshand Wind Farm project with a total capacity of 52 MW. Expected to be completed by the end of 2016, the Sainshand Wind Farm project located in the south-eastern sub-region, is projected to produce a total of 190 GWh of electricity every year. In addition to the grid-connected wind farms, there are also off-grid village-scale small wind power systems with an aggregated installed capacity of 1 040 kW (Table 4).

Thirteen aimag have more than 20 000 megawatts of wind potential, nine aimag have more than 50 000 megawatts of wind potential, and the Omnogobi aimag alone has 300 000 megawatts of wind potential. Regardless, Mongolia can hardly find a sufficient amount of demand to justify investment to capitalise on this potential, even if grid stability does not cause an issue. For off-grid wind turbines installed in rural areas, the prospects are fairly good. An estimated 4 000 such wind systems have been installed for the nomadic population.

On the other hand, wind maps have clearly shown that the south-eastern sub-region, *i.e.* part of the Gobi Desert that shares a border with China, has the best wind resources, with a significant area of wind speeds higher than 9.0 metres/second at 80 metre high, as shown in Figure 11. This suggests wind power exportation is a promising option if the infrastructure can be developed to support the power trade with its neighbouring country, or countries, in case the interconnected grid is expanded to other countries. Towards this end, the Oyu Tolgoi wind power project in Khanbogd soum, Umnugovi province, was proposed in 2010 by Clean Energy LLC[19] for potential exportation of wind-generated electricity to China through an interconnected grid. It would have an installed capacity of 250 MW.

15 Wind power density is more than 300 W/m^2.
16 Under the assumptions of turbine size of 500 kW, turbine spacing of 10D by 5D and 6.9 MW/km^2.
17 Equivalent to 5% of the Central Energy System grid's total installed capacity.
18 IPP to sell electricity to the grid at the agreed price stipulated in a PPA. In Mongolia, it will guarantee 0.095 USD/kWh for power purchase from the wind project investor for the lifetime of the project.
19 The Clean Energy Company was founded in December 2004 to develop wind power projects in Mongolia. It has built the first wind farm in Salkhit near Ulaanbaatar. The company announced that it was planning to develop four more wind farms in Mongolia with the total installed generating capacity of 400 MW.

Figure 11. Wind energy resource in the Gobi Desert region of Mongolia



Global Atlas for Renewable Energy, IRENA, 2015

Solar photovoltaics and thermal energy

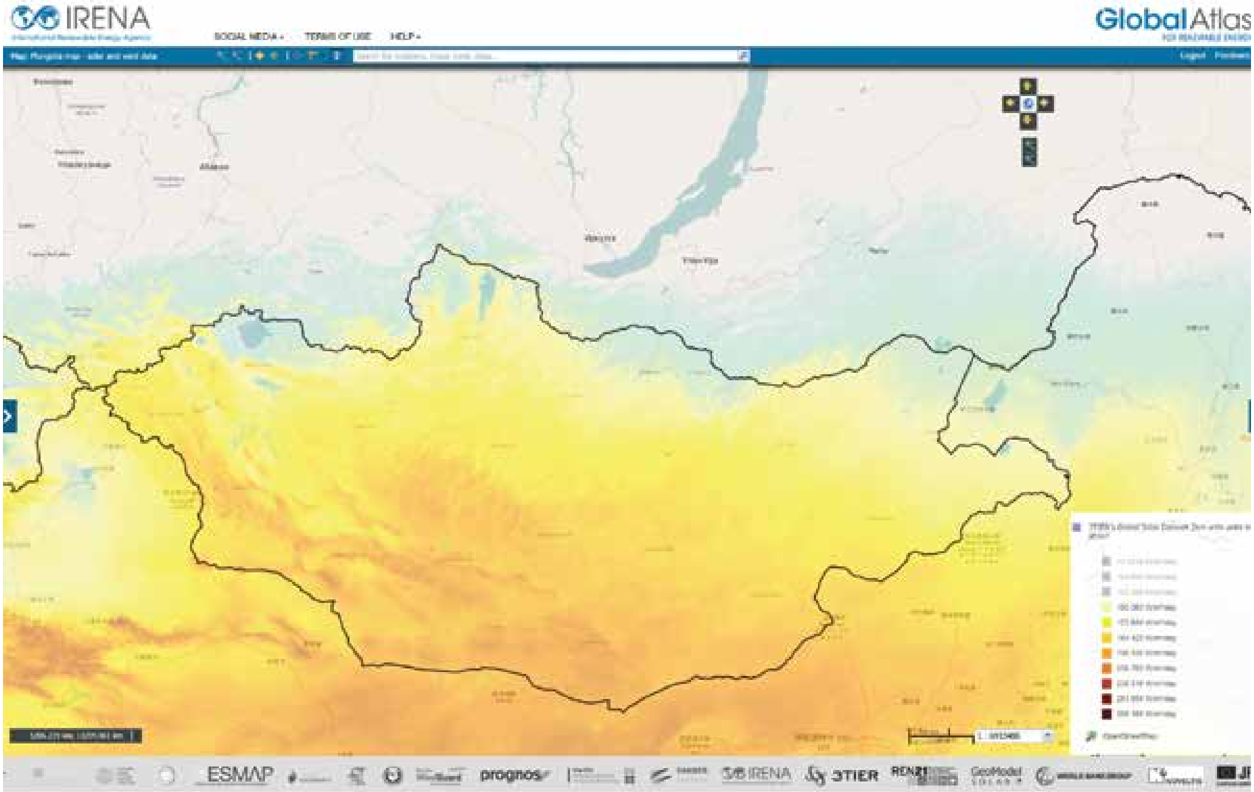
On average, Mongolia has 270-300 sunny days annually and an estimated 2 250-3 300 hours of daylight in a typical year. This indicates that the availability of solar radiation in Mongolia is fairly reliable. With average daily solar energy at the range of 3.4-5.4 kWh/m² in a total area of 23 461 km², Mongolia can yield 4 774 TWh of solar electricity per year, as shown in Table 3. With an estimated average solar electricity generation potential of 5.4kWh/m²/ day, in an area of 5 542 km², NREL calculations rank the Gobi Desert as the third highest on the list of the world's deserts with high solar electricity generation potential, as shown in Figure 12. The Gobi Desert sub-region that shares a border with China is also the site of an overlap between this excellent solar energy resource and an excellent wind resource, making this area a priority as far as renewable electricity exportation is concerned.

Table 3. Mongolian solar resource (estimates)

Solar radiation (kWh/m²/day)	Land area (km²)	Total solar resource (TWh/year)
3.4	5 269	654
3.8	3 924	544
4.1	4 210	630
4.5	4 515	742
5.4	5 542	1 092
Total	23 461	4 774

Source: US National Renewable Energy Laboratory, National Renewable Energy Centre of Mongolia.

Figure 12. Solar energy resource of the Gobi Desert region of Mongolia



Source: NREL (U.S) and National Renewable Energy Centre of Mongolia

The total currently installed solar PV power generating capacity has been estimated at 6 000 kW. As shown in Table 4, there are seven off-grid village-scale solar PV power systems with a total installed capacity of 1 000 kW and two grid-connected systems with the capacity of 500 kW. Since 2002, under the Renewable Energy and Rural Electricity Access Project assisted by the World Bank and other donors, more than 100 000 solar home systems have been provided for about half a million people – 70% of the nomadic population. The aggregated generating capacity of these systems is about 5 000 kW.

Wind turbines in Inner Mongolia
Photo: Shutterstock

Table 4. Solar PV systems (off-grid and grid-connected mini-grids) in Mongolia

Solar PV system	Location	Scale (kW)	Comments
Off-grid			
Noyon Solar System	Noyon soum, Umnugovi province	200	When Noyon soum was connected to the grid, the solar PV system was moved to the centre of Khatanbulag soum in Domogovi province.
Tsetseg Solar System	Tsetseg soum, Khovd province	100	When Tsetseg soum was connected to the grid, the solar PV system was moved to the centre of Altai soum in Govi-Altai province
Bugat Solar System	Bugat soum, Govi-Altai province	140	in operation
Altai Solar System	Altai soum, Govi-Altai province	200	in operation
Bayantooroi Solar PV System	Bayantooroi bagh, Tsogt soum, Govi-Altai province	100	in operation
Durvuljin Solar PV System	Durvuljin soum, Zavkhan province	150	in operation
Urgamai Solar PV System	Urgamai soum, Zavkhan province	150	in operation
Sub-total		1 040	
Grid-connected			
Chinggis Khan Air-port Solar PV System	Chinggis Khan Airport, Ulaanbaatar	443	In operation
Jargalant Solar PV System	Jargalant soum, Khovd province	50	In operation
Sub-total		493	
Total	**1 533 kW**		

Source: Energy Sector Statistics, published by the Energy Regulatory Commission of Mongolia, 2013

In addition to solar PV systems, there are six solar-wind hybrid generation systems with a total installed generating capacity of 870 kW, as presented in Table 5. Unfortunately, only the Tseel System is still in operation.

Table 5. Solar-wind hybrid systems in Mongolia

System location	Total capacity in kW (PV/wind breakdown)	Operational status
Tseel, Gobi-Altai Aimag	150 (30/120)	Yes
Manlai, Umnugobi Aimag	150 (30/120)	No
Shinejinst, Bayankhongor Aimag	150 (30/120)	No
Bayan-Undur, Bayankhongor Aimag	150 (30/120)	No
Bayantsagaan, Bayankhongor Aimag	150 (30/120)	No
Matad, Dornod Aimag	120 (30/90)	No

Source: Energy Sector Statistics, published by Energy Regulatory Commission of Mongolia, 2013

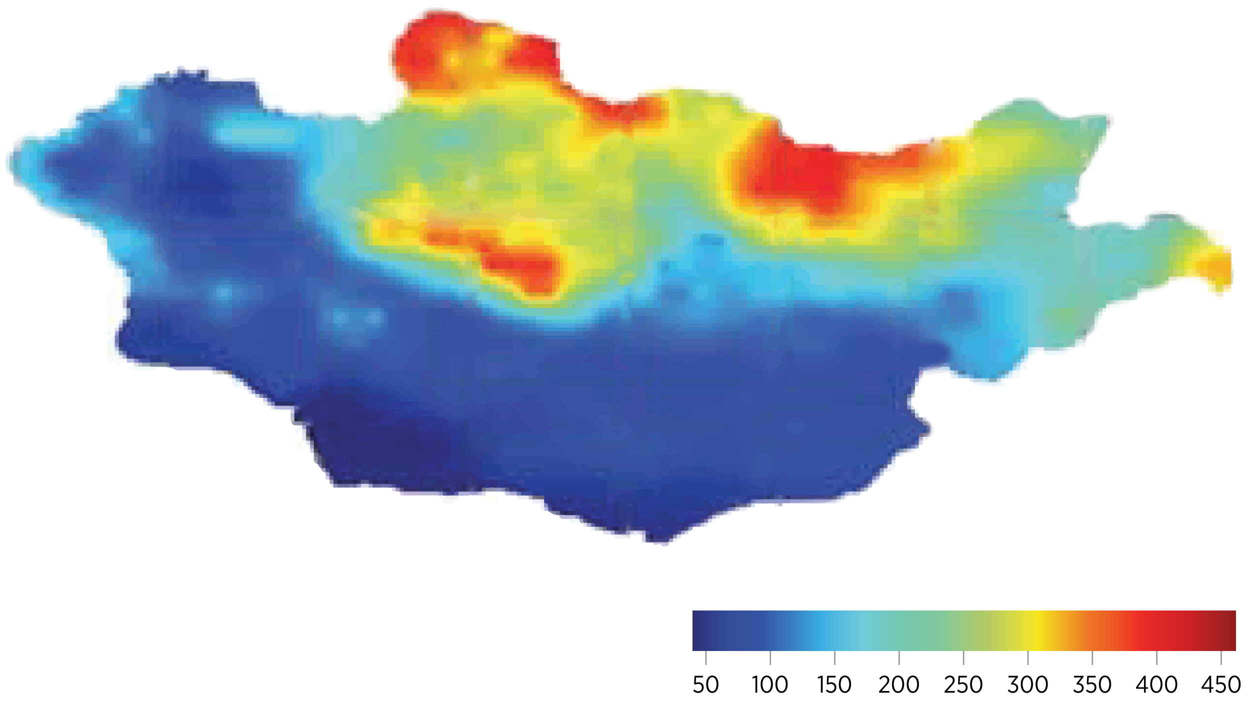
Centralised heating from solar energy is one of the solutions to provide cleaner, more sustainable heating services in government buildings, kindergartens, schools, hospitals, individual houses in soum centres and districts. Central solar heating provides heating and hot water based on the sun's energy. Water is heated centrally with arrays of solar thermal collectors and distributed via district-heating pipe networks. Compared to smaller, household-level solar heating, central solar heating offers better price-performance ratios, reflecting lower installation prices, higher thermal efficiency and less maintenance (Solarus, n.d.). Given the extensive availability of land, many places in Mongolia would be suitable for the establishment of large-scale central solar heating systems. However, the use of solar heating has not progressed, except for tourist camps and private houses with individually-installed solar water heaters.

Another application of solar thermal energy is Concentrated Solar Power (CSP), which uses mirrors to focus sunlight to either vertical pipes (parabolic troughs) or to a single point tank (solar tower), in which heat transfer fluid, typically water or oil, is heated and used to evaporate steam for ordinary thermal power processes. CSP is typically used for utility-scale applications and can generate heat for electrical production using steam turbines. If a CSP plant is equipped with a sufficient amount of energy storage, it can help meet the base-load demand. Solar irradiation in southern Mongolia is sufficient for CSP based on the fact that CSP projects have been implemented under similar irradiation levels in Spain. More importantly, Mongolia has 270-330 clear days, which is an important indicator for CSP applications, as it requires direct sunlight. However, operating CSP plants in the winter season is challenging for Mongolia due to its low seasonal temperatures, which might put high requirements on heat transfer fluid, which has to remain unfrozen to avoid catastrophic damage to the CSP system.

Hydropower

In general, annual precipitation is low and its distribution varies in time and space with a digressive pattern from north to south and from east to west, as illustrated in Figure 13. Combined with the mountainous topography in the north, rivers are most extensively developed in that region. Precipitation is seasonal and it is higher in summer, with rainfall filling up rivers and streams to their fullest in a year. There is generally much less rainfall in autumn. In winter, all rivers, lakes and streams are frozen, while the impact on power generation varies.

Figure 13. Geographical distribution of annual total precipitation of Mongolia



Source: Institute of Meteorology and Hydrology of Mongolia

In comparison with the realistic potential of 1 200 MW to 3 800 MW from the 2013 Water Management Report, published by the MEGD, the aggregated installed generating capacity of only 28 MW from 13 hydropower stations is extremely modest. Out of the 13 hydropower stations, only nine are in operation, including the two largest ones: Durgun with 12 MW and Taishir with 11 MW. This indicates that much of the identified potential has yet to be utilised. To develop these untapped resources, a so-called "Hydropower Master Plan" has been developed by a Turkish company called ZTM and was now under review by the MoE.

There is a recent move towards developing large hydropower in Mongolia. The planned 220 MW Egiin Hydroelectric Power Generation project, located on the Eg River, which is a tributary of the Selenga River close to the Central Energy System, has recently been scaled-up to 315 MW with annual generation of 606 GWh. The project has passed the preliminary feasibility study and environment impact assessment. Russia, which shares the trans-boundary Selenge River, has expressed concerns over the plan.

The Mongolian government has decided to proceed with Egiin Hydroelectric Power Generation project in 2016, having already begun the construction of roads, bridges and a high voltage transmission line. The planned Shuren hydropower schemes, including a 240 MW facility on the Selenge, faces a similar challenge that has to be addressed before the project can move forward. The feasibility study for the proposed hydropower project on the Hovd River in the western area has been completed and is under government review.

In addition, the facility's applications are intended to extend the hydropower scheme into pumped storage, which can facilitate the integration of solar and/wind farms into the power system by enhancing the flexibility required, if geographic conditions allow. Private companies are increasingly interested in developing pumped storage projects. For instance, the Tuul-Songino Water Resources Complex project proposed by a private company is to install 100 MW pumped storage capacity used as a regulating power for daily load consumption and potentially also for variable renewable energy sources.

However, the viability of pumped storage schemes would be negatively impacted if any of the planned large hydropower projects constructed play the role of power regulator as a pumped storage station plays. Therefore, its long-term economic viability must be scrutinised.

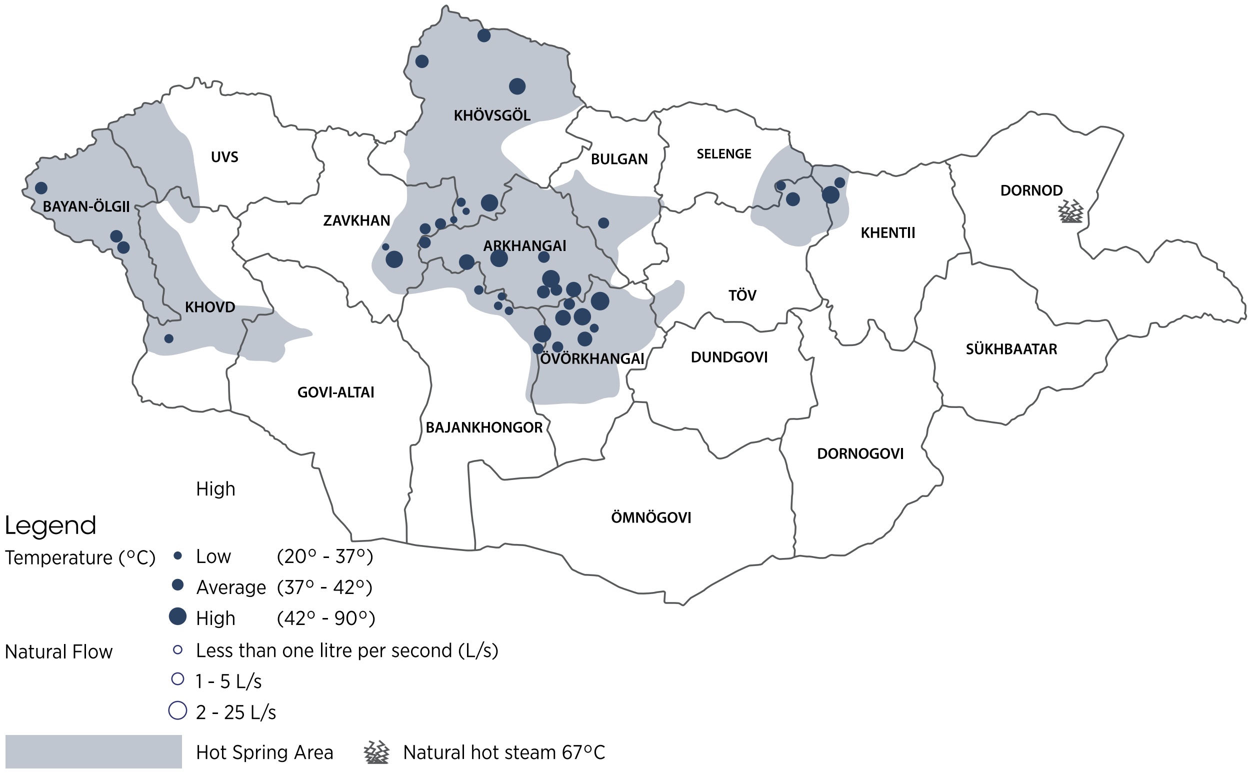
Geothermal

Given Mongolia is on a consolidated tectonic plate, theoretically it can hardly have a high degree of geothermal resources. But, without comprehensive geothermal resource surveys, this resource has yet to be fully explored and developed.

So far, 43 small hot springs in Khangai, Khentii, Khuvsgul, Mongolian Altai Mountains, the Dornod-Darigangiin Steppe and the Orhon-Selenge region have been explored, as illustrated in Figure 14. Despite the fact that the techno-economic analysis on those spots is lacking, small-scale non-commercial applications have been applied, such as for bathing, health resorts (balneology) and a small amount for heating greenhouses and buildings.

However, a pre-feasibility study by Icelandic consultants concluded that geothermal energy in hot springs with the surface temperature of more than 80 degrees centigrade (°C) might be economically developed to supply heat to Tsetserleg and other towns in the Arkhanghai area, but so far geothermal utilisation is not widely developed. Some preliminary studies estimate that the cumulative flows of usable heat (>35°C) from hot springs at aimag levels, are between 1 to 15 megawatt-thermal (MWth). The impact of this resource to Mongolia's overall energy supply may therefore remain limited and very local.

Figure 14. Geothermal energy resource of Mongolia



Source: US National Renewable Energy Laboratory, Renewable Energy Corporation of Mongolia

Bioenergy

Mongolians livestock herders have long used dried cow dung and khurzun[20] for fuel (Sarangerel, n.d.). The tradition continues, particularly in regions with little or no forest. Additionally, some 1 million hectares of unused arable land is reportedly suitable for production of biodiesel (Sarangerel, n.d.).

In the realm of biofuels, little has been done, although the Japan International Co-operation Agency (JICA) reportedly conducted research into Mongolian biofuel potential as early as 1993. According to some assessments, Mongolia could develop biofuel by growing corn in wheat fields that were abandoned when the Russians departed the country. While Mongolia imports almost 100% of its oil products, the opportunity to develop biodiesel deserves further study.

3.2 Government Commitments

Green Development Policy

In June 2014, the Green Development Policy was approved through the 43rd resolution of the Parliament of Mongolia (State Great Khural). The policy serves as a guideline for transition to green development. It not only elaborates the challenges that Mongolia has to address by embracing the strategy, but also identifies the opportunities embedded in such a transition.

More importantly, the policy calls for a "reduction of greenhouse gas emissions in the energy sector through increased energy efficiency by 20% by 2030, ensuring the share of renewable energy in total energy production to 20% and 30% by 2020 and 2030, respectively, and by renewing energy and industrial sector technologies, reducing wasteful consumption and losses and through optimisation of pricing policies." (3.1.1).

Under 4.2 Criteria and Expected Results, the policy lists the target share of renewable energy in total installed capacity of energy production to be 20% in 2020[21] and 30% in 2030. One should note that by issuing this policy and the specific action plan, the government went into installed capacity-based target setting.

[20] Khurzun is the hardened dung and urine of sheep and goats, with the average energy density of 12 500-14 600 kilojoules/kilogramme (kJ/kg) (Sarangerel, n.d. p.17).

[21] It was revised to the year 2023 to achieve this target in the State Policy of Energy.

State Energy Sector Policy

The Government of Mongolia recognises the significance of green growth in its long-term economic strategies for the country. With abundant potential, yet limited applications of renewables to date, the government has set renewable targets for the years 2023 and 2030 in the State Energy Sector Policy. This new piece of policy aims to transform Mongolia into an energy exporter underpinned by advanced and environmentally friendly energy technologies that can be adopted on a competitive market regime. To realise this strategic vision, specific objectives and goals were developed, followed by a strategy for implementation in two stages: 2015-2023 and 2024-2030. Proposals call for the policy to be updated every 10 years.

A two-fold increase of installed capacity is expected to be achieved in the first stage, and as a result, 10% reserve capacity can be built providing greater flexibility to integrate more renewable energy sources in the power system. In addition, the electricity tariff structure will be modified to increase the economic attractiveness for private investors and/or IPPs as well as to ensure that the operation of existing energy companies is economically viable. The government aims to achieve 100% energy access by this stage, indicating more stand-alone household renewable-based electricity generation systems to be used by nomadic herders, while at the same time, high capacity transmission infrastructure will be developed in co-operation with other countries.

In stage two, the focus lies on energy exportation and scale-up of renewable energy deployment. Two targets were set, *i.e.* reserve capacity of a minimum of 20% and renewable share of total installed generating capacity of 30%. By then, Mongolia shall be able to export electricity to neighbouring countries through HVDC electric power transmission lines while domestically enhancing the national grid network with information technologies for smart transmission, management, control, and monitoring. At the distribution level, the operation will be on a competitive market-based scheme for establishing an electricity retail market segment.

Mongolia's Renewable Energy Law

Mongolia's Renewable Energy Law was approved by parliament on 11 January 2007. In support of the 2005 National Renewable Energy Programme targets, the law was launched to specify duties and rights of entities generating and transmitting energy produced from renewable sources, and the main provisions of power purchase/sale agreements to be concluded between them.

The purpose of this law is to regulate the generation and supply of energy based on renewable sources, and is applicable to legal entities generating and delivering heat and electricity. More specifically, the law defined roles, rights and privileges of participants in construction of renewable energy power sources, issuing of special licenses, defining tariffs and power purchase agreement negotiations.

In addition, the law specifies the powers of state authorities with regards to renewable energy:

- The state parliament shall define state policies on renewable energy and make decisions on construction of power generating facilities to be financed from the state budget;

- The cabinet shall ensure implementation of the law and define soum where consumers are eligible for power supply from stand-alone renewable sources;

- The state administrative authority in charge of energy is empowered to develop state policies on renewable energy, to carry out feasibility studies, to draft standards on operation, safety and maintenance of the renewable energy equipment, to develop and approve rules and procedures on implementation of the Renewable Energy Law;

- Governors of aimags, the capital city of Ulaanbaatar, soum and districts, are authorised to include renewable energy facilities in land development plans, and to allocate land plots for construction of the said facilities; and

- The Energy Regulatory Commission (ERC) shall review tariff applications of generation license holders, and approve a template for agreements between generation and transmission companies.

Any entity intending to generate energy from renewable sources is required to apply for a license as specified in the Renewable Energy Law. The law also specifies duties and rights of entities generating and transmitting energy produced from renewable sources, and the main provisions of power purchase/sale agreements to be concluded between them.

Tariff differences between energy produced by renewable and conventional sources are required to be included in tariffs of other licensees connected to the grid, *i.e.* a cross-subsidy mechanism encourages renewable-based power generation.

The law stipulates the establishment of a special Renewable Energy Fund, from which 50% is meant to be financed by collections from state and local property entities and from institutions through selling of certified emission reduction units in compliance with the Kyoto Protocol. In practice, the main sources of funds are provided by the CHPs. However, the fund has a zero balance because the financial difficulties of the CHP plants have precluded them from contributing to the fund as required by the Renewable Energy Law.

As one of the instruments that the law brought into the regulatory regime, FiTs[22] were introduced to create an enabling environment for the private sector to actively engage itself with the development of renewable energy markets. They were also intended to attract investments in renewable energy project development under seven special licenses issued, for a total installed generating capacity of 534.2 MW. A PPA was also developed and used as a legally binding document between the state-owned Central Regional Electricity Transmission Network and any private renewable energy developers or electricity producers, to make sure the electricity generated from renewable sources is sold at favourable prices.

The ERC of Mongolia, as a power sector regulator, is obliged to give the green light to any signed PPA that is based on FiTs, whose tariff structure supports a specific source of renewable energy can be seen in Table 6.

However, existing electricity prices are still distorted due to coal power subsidies. Additionally, the legal framework, particularly to ensure the priority of dispatching renewables, is missing and institutional capacity to deal with the large-scale on-grid variable renewables, is weak. The Renewable Energy Law sets specific ranges of FiTs for energy generated from renewable sources and for its delivery to utility. The ERC has regulations for geothermal and biomass electricity generation; however, they are not as clearly defined as other renewable sources. In the law, it stipulates that USD shall be used to pay FiTs in favour of private investments flowing in to the renewable energy market. This has been well received, as it does indeed significantly reduce the currency exchange risks to which foreign investors are exposed. However, it has also been recognised that the financial pressure on the government has been mounting as a consequence of the weakened Mongolian currency.

[22] Article 11 of the Renewable Energy Law established feed-in-tariffs for wind, hydro, and solar sources both on and off the grid.

Table 6. Ranges of FiTs for renewable energy power sources in Mongolia (USD/kWh)

	Hydropower			Wind	Solar
	Up to 500 kW	500 – 2 000 kW	2 000 – 5 000 kW		
Grid-connected	0.045-0.06	0.045-0.07	0.045-0.08	0.08-0.095	0.15-0.18
Off-grid	0.08-0.10	0.05-0.06	0.045-0.08	0.10-0.15	0.20-0.30

Source: Renewable Energy Law of Mongolia, 2007

Since 2013, there has been serious discussions in Mongolia with respect to how to address the emerging issues arising from the implementation of the Mongolian Renewable Energy Law over the past eight years and improve the overall enabling environment. As a result, amendments to the law were crafted and the amended law was passed in parliament in June 2015, in hope of enhancing investor confidence in Mongolia's renewable sector. The key elements in the amendments include:

- **A support tariff.** This will be set by the Energy Regulatory Authority and is intended to pay the premium that was supposed to be covered by the Renewable Energy Fund, as designed by the Renewable Energy Law.

- **A renewable power mandate for the MoE.** The ministry should prepare and approve grid code and regulatory requirements for connection and transmission of electricity from renewable sources. This will help integrate renewables into distribution system. The MoE is also to prepare and enforce standards for renewable energy equipment, operation and maintaence.

- **Three new mandates for the Energy Regulatory Authority.** These include: a) approving a model agreement for use between generators and transmitters and monitoring the implementation of such agreements; b) setting the amount of a support tariff for consumers; and c) estimating energy tariffs after the expiration of a power purchase agreement.[23]

- **Guidelines for PPAs.** A clause added through an amendment to the Renewable Energy Law addresses the issue of lack of maximum limit on the number of years of commitment on the part of the government upon entering into a PPA with a renewable power generators. It stipulates that "the power purchase agreement validity term should be set in accordance with investment payback period".

The legal framework for ensuring dispatch priority of renewables is still missing – an issue causing curtailments in the power output from the first wind farm installed near Ulaanbaatar.

[23] According to an unofficial translation provided by the Ministry of Energy of Mongolia.

Clean Development Mechanism (CDM) and Joint Crediting Mechanism (JCM)

In 2002, the Government of Mongolia established the National Committee on Climate Change, which was chaired by the Minister of Nature & Environment with high-level representation from the several relevant ministries. The committee has three working groups, including one on public-private partnerships, a Clean Development Mechanism (CDM), and a working group on energy efficiency.

Assisting with project development, approval, and implementation of CDM initiatives, the designated national authorities within the CDM included the Ministry for Nature and Environment, Ministry of Fuel & Energy, Ministry of Industry and Trade, Ministry of Finance and Economics, various scientific organisations, NGOs, and the private sector. CDM projects can fall into five categories including heat efficiency, renewable energy, technology transfer, greening or reforestation, and environmental pollution. In 2012, five out of a total of nine CDM projects, or 71%, constituted renewable energy programmes while two or 29% constituted energy efficiency (Dagvadorj, 2012). Registered under the CDM, two hydropower projects including those in Tashir and Durgun, are estimated to reduce emissions by 30 000 tonnes of carbon dioxide annually.

Japan initiated the Joint Crediting Mechanism (JCM) as a tool to complement CDM under the UNFCCC, with the aim of facilitating widespread applications of low-carbon technologies, and ultimately reduce emissions of greenhouse gases. Implementation in Mongolia has been focused on high-tech low-carbon technologies that can be applied by the private sector in 13 identified sectors. Japan will cover 50% of the project costs and in return will take the carbon reduction credits generated from the subsidised projects till 2020.

Nationally Appropriate Mitigation Actions (NAMAs)

Nationally Appropriate Mitigation Actions (NAMAs) are nationally determined policies and actions that reduce GHG emissions below the business-as-usual scenario. With support from developed countries, NAMAs are voluntarily selected and undertaken by developing countries. In Mongolia, NAMAs can provide a practical framework for promotion of sustainable development by selecting mitigation actions that reduce vulnerability to climate change while also supporting the achievement of national development goals.

In 2010, Mongolia submitted its NAMAs to the UNFCCC Secretariat. For the energy sector, Mongolia has set the objective of increasing renewable energy options in supply through NAMAs such as installation of large-scale PV systems in the Gobi Desert region, placement of 100-150 kW wind turbine generators in provincial centres in the southern part, and encouragement for the development of small- and medium-sized hydro power plants.

Mongolia is preparing to operationalise NAMAs in Mongolia with a list of potential projects being identified in energy intensive sectors such as cement and construction. Energy-efficient lamp bulb substitution is also one focused area.

Intended Nationally Determined Contribution (INDC)

Intended Nationally Determined Contributions (INDCs) are designed to complement existing schemes, such as CDMs and NAMAs, following the principle that each participating country should choose actions in accordance with its own capacity and interest. Such contributions are intended to reduce GHG emissions and can also enhance a country's capacity to adapt in the changing climate. By 1 October 2015, the pledges received amounted to 119 INDCs, representing 86% of global GHG emissions.

Mongolia has submitted an INDC (UNFCCC, 2015), which underlines the country's political commitment to join global efforts to keep the increase of mean surface temperatures within a limit of 2°C, or even 1.5°C, by the end of this century. The proposed actions on renewable energy include the targets set in state policy on energy (Parliament resolution No. 63, 2015), which is in line with green development policy approved in 2014.

More specifically, to achieve the targets, an estimated 675 MW of hydropower, 354 MW wind and 145 MW solar PV power generation capacities, would be added, which would require investment of USD 2 500 million, according to the analysis based on IEAP (Long-range Energy Alternative Planning) model and IPCC cost data.

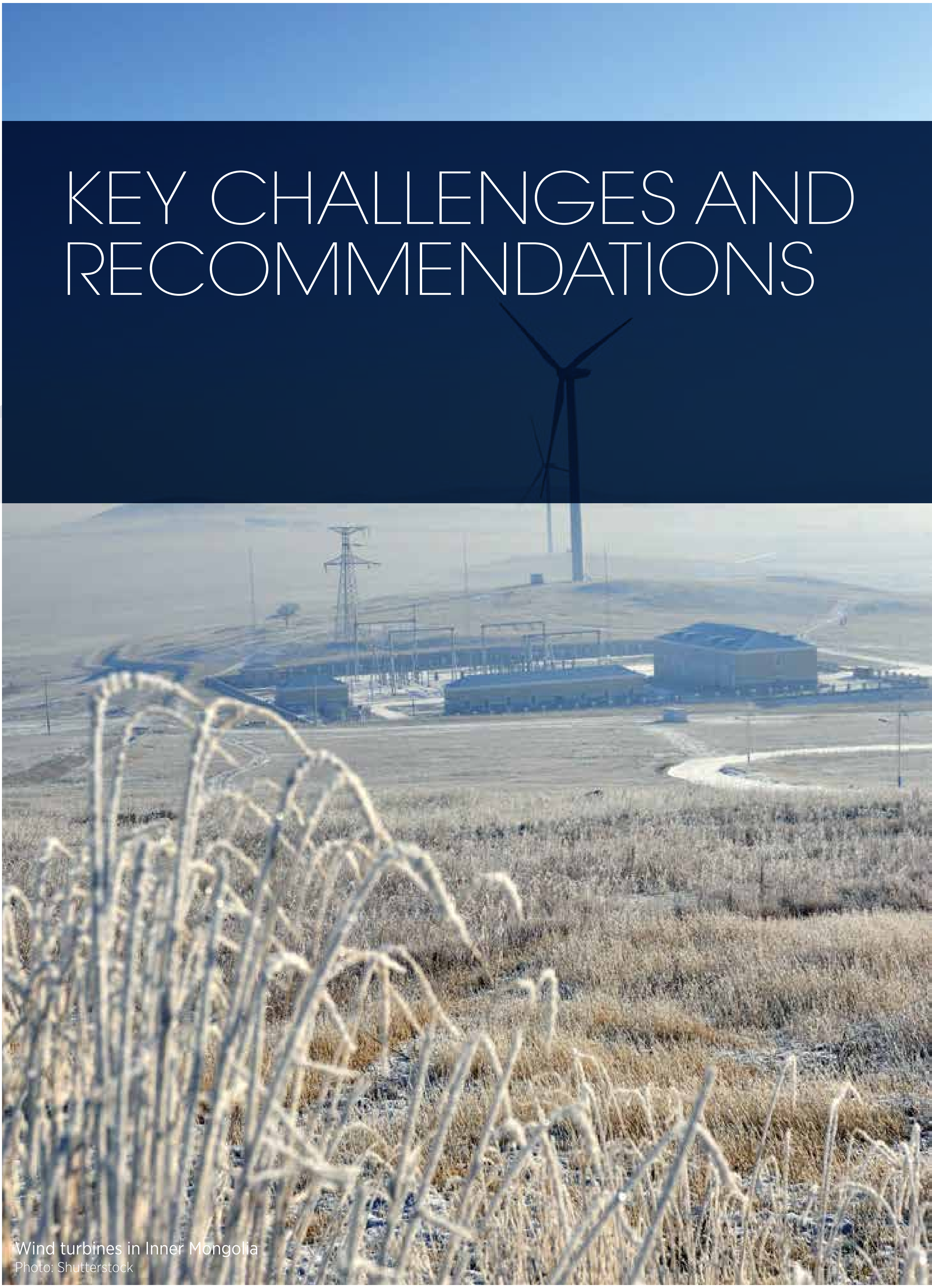
Strategies for Development of Green Energy Systems in Mongolia

In 2012, the Government of Mongolia announced that green development would be the new economic development strategy of the country. To facilitate this, the government established the MEGD. The Global Green Growth Institute (GGGI) is assisting Mongolia in developing and implementing a national green growth plan within the transport and energy sectors. The Strategies for Development of Green Energy Systems in Mongolia project was completed in early 2014 by the GGGI in collaboration with the Mongolian government, Stockholm Environment Institute, and the United States.

With the objective of promoting the development of green energy systems in Mongolia, the project developed a quantitative computer model for determining Mongolia's potential energy future and GHG emissions through 2035. The model was used to generate predictions for Mongolia's energy and GHG in four different scenarios. The reference scenario provided a case for continued use of coal-based energy systems and predicted an estimated fourfold growth in annual GHG emissions along with a 200% increase in energy consumption by 2035.

On the opposite end of the spectrum, the Visionary Shift in Energy Exports Scenario developed based on Long-Range Energy Assessment Planning (LEAP) model results provided a case for widespread incorporation of extensive wind and solar power generators in line with the country's strategic vision, which is to transform Mongolia into a key net green energy exporter in the region. To achieve this ultimate goal, exporting coal should be replaced by renewable electricity. This scenario becomes increasingly plausible, as China is moving towards curbing its emissions and combat local/regional pollution caused by coal burning. The bilateral exportation of electricity is expected to be extended to the regional level – the core concept of the ASG.

KEY CHALLENGES AND RECOMMENDATIONS



Wind turbines in Inner Mongolia
Photo: Shutterstock

04

Through the RRA process, participants identified challenges hampering the development of renewable energy sources in Mongolia and subsequently helped to formulate recommendations to address those challenges. The present chapter outlines those key challenges and recommendations.

4.1 Core Elements of the Enabling Environment

To tap Mongolia's vast renewable energy resources, the government has set ambitious targets for development of the sector. With existing policies, as well as extensive discussions among policymakers about further green growth development, Mongolia appears to be on the right track to accelerate the development of renewables.

However, scale-up has yet to take off. Projects prepared or planned by private investors and developers still encounter challenges. Yet enthusiasm in the private sector remains high for Mongolian renewable energy development. Energy experts estimate that about 450-500 MW of wind and solar PV generating capacity could be installed comparatively easily, if certain uncertainties about current investment were removed, and if national and local renewable energy policies would be implemented in a co-ordinated and consistent way.

Challenges

The Renewable Energy Law has not been strictly enforced. With the introduction of the Renewable Energy Law in 2007, FiTs for various renewable energy technologies were established. Incentives from the FiT programme have prompted the initiation of several solar and wind farm projects by private companies. However, room for improvement has been identified after years of operation following passage of the law. For example, two major issues related to FiTs have created uncertainties for investors and developers as well as for the government, the amendment of the law. The first issue was the duration of FiTs, which was resolved in the amendment of the law passed in June 2015.

Another relevant issue is the currency used for FiTs. In the law, it stipulates that FiTs shall be paid in US dollars, which favours foreign investors by eliminating their currency exchange risk. The government was originally intended to encourage foreign investments in renewable energy projects in Mongolia. This has been well received by foreign investors and developers, and should be sustained. However, when the Mongolian currency depreciated against the dollar dramatically in previous years, the financial pressure on the government to pay the investors in dollars for renewable electricity began to mount.

At present, a major issue is the insufficient financing for renewable energy projects by the government through the Renewable Energy Fund, which was created by law but remains on paper until now. Without a replenishable source to cover the incremental cost and the mounting pressure on governmental fiscal budget, future investments in, and expansion of, renewable energy applications in Mongolia may be discouraged.

General recommendations

Long-term price guarantees, provided through either law or PPA, could reduce the risks associated with investment in renewables, especially in the absence of sufficiently developed financial markets and products for risk hedging. If adequately supported by independent and accountable institutions, reliable and transparent policy formulation, this could serve as an effective mechanism for facilitating project developers or investors to gain access to bank loans on favourable terms.

In addition to the long-term price guarantee, the government needs to allocate sufficient funds to establish a well-designed and managed fund that ensures foreseeability, transparency and fairness. Along with budget allocation, the government would also need to take necessary measures to raise and secure funds by ensuring the existence of adequate support policy for the long-term use of soft loans and making special requests for technical assistance and grants from international financial institutions and donor countries and private investors, if needed.

ACTION 1: Investigate the potential of a renewable energy quota system

The feasibility of applying a quota system in Mongolia should be studied. Such a system would enable the creation of a market fostering renewable power generation and facilitate the achievement of the renewable energy targets set by the government. A system with tradable quotas, also known as the Renewable Portfolio Standard or tradable green certificates, assigns quota obligations for power grid enterprises, large-scale power-invested enterprises and local governments, whereby a certain percentage of their electricity must be generated from renewables, either directly or by purchasing renewable electricity credits.

The quota system has to be carefully designed, managed and adapted in order to become a cost-effective policy scheme. One of the main benefits of this scheme is the fact that price discovery can be partially market-based and technology neutrality can ensure least-cost choices by investors.

Among governmental support tools, quotas apply the most market-based approach. The ability to trade certificates also allows for regional approaches across borders, providing the potential for further cost reductions. Extra costs associated with some renewable investments are often passed on to electricity consumers, eliminating any obligation for the government to pay, or for suppliers and/or investors to accumulate debt.

Quotas can be a strategic move in preparing the country for a regional renewable electricity market, assuming the cross-border power grid infrastructure can be developed with neighbouring China, where a similar scheme is under way. A regional market for tradable renewable electricity certificates would provide an additional stream of revenue to Mongolia.

ACTION 2: Allocate financial resources for renewable energy promotion in the annual government budget

The annual centralised budget of the government must include funds to maintain support policies such as soft loans and technical assistance. Developing a public-private partnership can help raise grants from international financial institutions, donor countries and private investors. Income tax rebates and credits for renewable energy projects, in particular import tax reductions for imported components and parts for renewable energy equipment may further encourage investment and accelerate the deployment of renewables. The budget for securing the Renewable Energy Fund could be stocked from a portion of the revenue from taxes on air pollution or fossil fuels, mining revenues, or electricity tariffs.

4.2 Grid Assessment for the Integration of Variable Renewables

Challenges

Lack of knowledge about current grid status raises grid-stability concerns. The Central Energy System grid has been dominated by coal-fired power plants. With Mongolia's first wind farm in operation for nearly two years, the grid operators have gained some experience in dealing with variable renewable sources and have also encountered some challenges. What worries Mongolian energy experts and grid operators is what could happen if more variable renewable energy is put on-line, and how to deal with the flexibility constraints that could ensue.

ACTION 3: Conduct a power-system status assessment and a study on grid integration

A survey was conducted before the first wind farm project was initiated, yielding the rather conservative result of about 10% variable renewables as the most the Central Energy System could take on. At the other end of spectrum, some experts estimated that the Central Energy System can accommodate more than 150 MW each of wind and solar PV, representing about 30% of the current total installed capacity.

From an energy planning perspective, there is a need to conduct a power-system status assessment to better understand which part of the grid can connect variable renewables without causing grid stability issues. The focus can be extended from centralised wind farms to distributed generation including both small-scale roof-top and utility-scale solar PV farms in place of substations. Power flow and stability analyses are needed, so as to provide a better understanding of how connecting variable renewable sources affects the grid. This would ensure such small-scale systems are safely accommodated, if and when Mongolia opens up its generation business to distribution companies by allowing them to install solar/wind systems within their service areas.

This analysis can help grid operators predict the grid response to solar or wind generation inputs at various points and different penetration levels. Computer modelling will help the grid operator, namely the NDC, establish the criteria that installations must meet before being allowed to connect.

However, computer models can address only part of the concern. The current state of the infrastructure and the quality of service, therefore, are important to asses. This avoids adding present network operational problems to the issues associated with integrating variable renewables.

The following should be included:

- Diagnostics of present infrastructure including generation, transmission and distribution networks.
- Grid assessment studies providing definitions of key unknowns:
    - hosting capacity (at system and distribution level);

- expansion requirements and network operational measures;
- PV/renewable energy deployment plans, in line with current hosting capacity and recommended measures;
- technical interconnection requirements (at rooftop and system level).

- Recommendations on technical interconnection requirements to support grid operation.

The results could also help policy makers develop suitable policy schemes to support the integration of variable renewables into the power system.

4.3 Institutional and Human Capacities

As the use of renewable sources rises, equipping officials in governmental energy authorities, practitioners, researchers, university graduates, politicians, political advisers with updated knowledge on subjects such as cost reduction, technological advancement, subsidy issues, policy schemes and potential environmental concerns, has increasingly become important. This requires enhancement of the institutional and human capacities of the Mongolian renewable energy sector.

Challenges

The country needs fully functional institutions for renewable energy. Although renewable energy is not a completely new sector in Mongolia, only a few skilled employees are able to undertake both management and planning functions and to perform financial analyses. Over the past years, it has been evident that there is a growing need to enhance the technical and co-ordination capacities of energy sector institutions in Mongolia to address the emerging issues arising from the increasing deployment and integration of renewables into the energy system. This much-needed capacity enhancement would also help the MoE as well as other governmental authorities involved in renewable energy development in Mongolia to gain a better understanding of the root causes of the issues they encounter, and mobilise necessary resources to not only address them but also prevent occurrence of future challenges through strategic energy planning.

However, public funding cuts imposed by the government for research, development, and demonstration of renewable technologies, as well as for resource assessment, has weakened the capacities of energy institutions in Mongolia.

There are, however, young graduates who are trying to enter the Mongolian renewables sector. There are two public universities where Bachelor's, Master's and Doctorate degrees in Renewable Energy can be obtained: the Mongolian University of Science and Technology, Power Engineering School; and the National University of Mongolia, School of Applied Physics and Engineering. Currently, more than 60 students graduate from public and private universities in Mongolia with a specialisation in the field of renewables every year. In addition, there are renewable energy specialisations in private schools, with 30-40 students trained per year. However, only a minority of the new graduates manage to find renewable energy-related jobs, mainly due to lack of the practical experience that employers require from applicants. Skills of technicians, competence of skilled employees, and the economic ability of institutions are often insufficient with respect to project implementation (GTZ report, 2009).

General recommendations

Government support to fund training, research and development, demonstration of technologies and resource assessments will play a critical role in determining whether renewable energy continues gain market share and can eventually become competitive with fossil-fuel technologies. This is especially true in the case of Mongolia, where there is an abundant supply of coal.

Therefore, to ensure that the institutional and human capacity for renewable energy development in the country can be sustained, the capacity of the NREC of Mongolia ought to be reviewed against this backdrop. With that, specific capacity enhancement programmes could be developed and delivered to the NREC, whereby it could be better integrated into the MoE by focusing on providing advisory services to the government through effective co-ordination and co-operation with other energy sector entities. Moreover, there is an urgent need for the country to devise key strategies for capacity building and growth of its renewable energy sector. The strategies should address evolving needs of the sector in the short-term (1-2 years) and medium-term (3-5 years), and at different levels, namely regarding institutional and human capacities.

ACTION 4: Establish a national research, development and training facility for renewable energy development

A strong national renewable energy facility, integrating research, development and training services, can play a pivotal role in accelerating the scaling up of renewables in the country in the present and future context, when more large-scale renewable energy systems are installed. For example, there is going to be a growing need to understand the behaviour of variable renewable sources on the grid, and if and when curtailment becomes inevitable, a third-party assessment will be necessary. The proposed facility would have an important role to play in resolving such disputable issues.

Such a facility can be built on the basis of the existing NREC,[24] based on the results from the review of the NREC's capacity and functionality. The best approach needs to be determined for the establishment of the new facility. One possible way is to make it part of the current NREC with necessary restructuring and reorganisation. A key element is that such a facility can be part of the governmental system, partially owned by the government, and therefore can be eligible to access the government budget to provide financial support for research and development activities, which is important for a country with a harsh natural environment to which renewable energy technologies will have to adapt.

The proposed facility is recommended to develop a geographic information system (GIS)-based renewable energy resource database. This would be publicly available, transparent, and updated on a regular basis, in high resolution, with time series pertaining to energy consumption, demand, and supply trends of the country. Such a database could be useful in potentially modelling and simulating the operation of Mongolian power supply with added renewable energy capacities, which would enhance the capacity to forecast trends for the variable nature of renewables, thereby facilitating planning and investment. The facility could also be well positioned to provide advisory services on energy and grid planning to governmental agencies.

In addition, the facility can serve as an interface between Mongolia and the rest of the world when it comes to knowledge exchange, collaboration and establishment of technical standards and quality assurance procedures for renewables in Mongolia.

Lastly, given the limited know-how on the technical aspects of operation and maintenance for renewable energy systems in rural areas, the facility should create one unit focused on rural electrification and other energy services that the rural or nomadic population may need.

The annual, centralised government budget must allocate sufficient funding for research, development, and innovation of renewables. For instance, adequate funding has to be allocated for the establishment and operation of laboratories at national universities dedicated to research, development and the promotion of renewable energy technologies. If the government decides to proceed with this, potential opportunities ought to be explored for collaborative efforts between

[24] Formerly the Renewable Energy Corporation, formed in 2000. The corporation was previously the Renewable Energy Institute (REI), created in 1980 as a subsidiary of the former Ministry of Fuel and Energy.

such renewables-focused laboratories and the proposed research facility.

Looking forward, functions such as advisory services for investors can eventually be operated on a commercial basis while services such as drafting energy policies for the MoE can remain as part of the mandates given to the NREC. Thus, the centre can act as the branch of the ministry to provide technical advisory services to other ministries and also co-ordinate with other energy institutions such as the NDC on various renewables-related issues. However, support from the government as well as the donor community is necessary, particularly in the initial phases of establishing the proposed research facility. The team can be set up with the help of IRENA and other contributors.

Challenges

The country lacks adequate institutional capacity and a dispatch priority mechanism for renewable energy. The Mongolian energy system in general, and the Central Energy System in particular, is highly complex in terms of significantly varied loads over the period of a day as well as seasonally, in addition to being dominated by coal-fired power plants that are not designed with great flexibility. By largely the same token, the NDC functioning as a grid operator has limited capacity to engage in power regulation from the control room due to the constraints that some power plants/CHPs have in adjusting their production to load variations about two years ago.

When the first utility-scale wind farm in Mongolia came on-line in 2013, the NDC had to deal with greater challenges; especially during the night, when energy demand was low while wind electricity generation was high. The NDC has chosen to give priority of dispatch to the electricity generated by thermal power plants and put curtailment on wind, due to the technical and economic constraints that coal-fired steam generators in the thermal power plants might encounter.

On the technical front, CHP steam turbines are able to respond in seconds to load dropping by having pressure reduction valves engaged. However, if and when the load remains too low and the steam generators at the thermal power plants are suppressed to the minimal level under which the steam generators can operate, a decision has to be made regarding further operation. The prevailing rule is to avoid shutting down the steam generators, as they are not technologically designed for start-stop operation, and therefore will have a shorter lifetime than designed/desired.

Hydropower plant, capacity 11 MW, Gobi-Altai province, Taishir soum
Photo: Luvsandandar, J.

From an economic perspective, shutting down and re-starting a steam generator/boiler is prohibitively costly. The high costs associated with the shutdown-restart are additional to the revenue loss caused by the reduced amount of electricity produced from thermal power plants compared to what would otherwise be the case. Lastly, if the curtailment is not applied while the Mongolian power grid cannot take it, another option is to export it to Russia at nearly zero value. In this case, Mongolia could even face Russian penalties, as the country is required to submit its import/export schedule in advance. In case of any deviation from the schedule, a penalty is imposed.

Having said that, as the newer CHPs are gradually put on line, there is a good opportunity for the conventional base-load power plants to follow the load and adapt to the impacts of variable renewable electricity. As far as the grid operators are concerned, there is a need for the NDC to overcome the increasing technical difficulties presented by variable renewable sources and receive dispatch training that can help guarantee priority of access to renewable power.

In addition, thermal power plants lack incentives to make efforts to adapt the new load profiles, taking into account variable wind power outputs.

General recommendation

With a growing share of variable renewable sources in the grid, new techniques and tools for grid operators to deal with the variation have been developed. This has provided potential solutions for the grid to take in high shares of variable renewables without jeopardising grid stability. The Mongolian dispatch centres should keep abreast of the best available practices and tools and also be involved grid stability studies, if any.

First of all, the grid operator, *i.e.* Mongolia's NDC, needs to overcome the increasing technical difficulties presented by variable renewable sources. To enable the NDC to do so, there is a need to enhance the operational capacity of the dispatch centre to deal with large-scale on-grid variable renewables to ensure priority of access to renewable sources. This can be followed by the creation of a regulating/ancillary service, or capacity market, to compensate the economic loss that would occur when CHPs have to operate under reduced load because of high outputs from variable renewable electricity generation facilities.

ACTION 5: Enhance National Dispatching Center capacity

There is a need to enhance the capacity of the dispatch centre to deal with large-scale on-grid variable renewables and ensure priority of access to renewable sources. This has to be improved in both physical and regulatory terms.

Improving power grid infrastructure

Physically, the Mongolian power system needs spinning reserves to make the grid more flexible as a means to address the variability of renewable power outputs. A more advanced control system is needed to regulate outputs from power plants directly from the control room of the dispatch centre. If this is done well, the present load issue can be less problematic in future, although it does have adverse impacts on the financial and technical performance of the wind farm at the moment.

Defining clear operational rules

Current dispatching regulations need to be revised and analysed after taking into consideration the significant fluctuations in renewable power output that could impede a low-cost daily supply-load balance. Based on that, the operational rules for dispatch orders should be clearly defined in favour of maximising the injection of electricity from renewable sources into the grid under the condition that grid stability is not compromised.

Integrating a wind forecasting programme into NDC operations

The NDC needs to know which units, including wind turbines, can be dispatched in the coming days, hours and minutes. Therefore, to accurately forecast the available wind resource is particularly important for the grid operator. An advanced wind resource forecast software/programme needs to be integrated into the NDC operation.

Enhancing the technical skills of operational staff

Training sessions are recommended for grid operators on the use of simulation tools to facilitate dealing with a greater share of solar and wind power in the grid. The capacity of dispatch centres can be further enhanced with forecasting techniques, such as day-ahead or six-hour-ahead forecasting and with the introduction of technical standards for renewable energy equipment and the operational behaviour of renewable power plants in the grid code. Appropriate tools should be made available and a series of training programmes should be carried out.

4.4 Developing Cross-border Grid Infrastructure to Export Renewable Electricity

The Mongolian power system is in great transition with the increased use of renewable-based systems to replace coal-fired power plants, moving both domestically and regionally (albeit at a more gradual pace) to maximise the utilisation of its vast amount of renewable energy sources, particularly in the Gobi Desert region. With the rising demand for cleaner energy sources in China and the other countries in the northern Asian region rises, Mongolia recognises the opportunity to reach its strategic goal of becoming an exporter of renewable electricity in the region.

Challenges

A comprehensive feasibility study is needed with a focus on techno-economic analysis. The notion of exporting Mongolian low-cost renewable-based electricity from the Gobi Desert to neighbouring countries, through the ASG, has increasingly attracted interest from investors and developers. However, due to the large geographical extent of the Gobi Desert region, along with the projected high upfront costs, the ASG project is facing an extraordinary set of technical and political challenges that hinder the progress of the project beyond its preliminary phase. Serious considerations of the technical, political, and socio-economic requirements, barriers, and implications must be carefully studied in order to successfully realise the potential of the ASG. These can include conducting detailed renewable energy resource assessments and determining the optimal land use, grid conditions, and location of dispatch centres.

A few preliminary studies on the issue of grid integration in northeast Asia have been completed by the Asia Pacific Energy Research Centre (APERC), the Korean Electrotechnology Research Institute (KERI), the Siberian Energy Institute of Russia and the Energy Charter. These reports identify the potential benefits and barriers to grid interconnection, but do so mainly from a research perspective. Initial studies indicate that Gobitec/ASG is technically and economically feasible. However, a comprehensive feasibility study to present different options with detailed techno-economic analysis has yet to be conducted, ideally with the involvement of the governments of the relevant countries.

Recommendations

Further progress in Gobitec/ASG strongly depends on detailed feasibility studies with close regional co-operation in the north eastern Asian region. Forming an electricity market in the region requires significant effort and negotiations to eliminate the physical, trade and regulatory barriers. As the countries have different energy targets and policy structures, the processes involved may present obstacles.

A convincing feasibility study will help the relevant nations understand the cost and long-term benefits of materialising this idea. With increasing pressure on reducing carbon emissions and conventional pollution from coal-fired power plants, the need for renewable electricity has been growing substantially over the past few years. This has been coupled with growth in electricity demand. Therefore, the governments in each of the ASG countries are on the verge of being engaged.

ACTION 6: Form a consortium to conduct a feasibility study

Specifically, a consortium should be formed among relevant countries, with support from the national governments in those countries, to conduct a comprehensive feasibility study. Gobitec will be relying mostly on large-scale wind and solar energy projects within the Gobi Desert region for potential energy exports to China, Japan, the Republic of Korea, and the Democratic People's Republic of Korea. Since there is no grid infrastructure in the Gobi Desert region, the economics and technical requirements for the development of the regional grid infrastructure need to be considered in the feasibility study. Experiences from other regional energy initiatives can be leveraged and best practices can be applied, depending on domestic suitability.

Such a study should involve regional and/or international organisations where a multilateral platform can be provided. Such an international platform can help provide legal guarantees for participating countries, investors and other stakeholders; can help in the alignment of their renewable energy targets; can provide a joint platform for electricity exchange with a harmonised set of trade and transit rules; and can improve the investment climate. The most important objective of the consortium is that co-operation should be structured in such a way that facilitates the equal distribution of project benefits among all participants, and assesses engineering challenges and solutions.

This means that the national governments in these countries should be more actively involved, and it should be made clear how the feasibility study results would be used, especially in mid- to long-term energy planning and development. International financial institutions, regional financiers and national banks will perceive potential investments as less risky when those are backed or endorsed by a government. With international/regional organisation participation, the investment risk can be reduced by providing a stable and transparent legal framework. Agreements reached on a multilateral basis are less likely to be breached. This setting would, in return, encourage engagement of the private sector for joint implementation of the ASG initiative, which is crucial. The Greater Mekong Sub-Regional Power Grid Interconnection project aided by the ADB may be a model that can be used to materialise the Gobitec/ASG concept.

To mitigate the risks, investments can start with smaller projects, which can subsequently be aligned with the Gobitec/ASG vision after the comprehensive feasibility study is completed. Such projects could be started nationally and then be evolved into bilateral and multilateral projects at a later stage.

In order to ensure that various environmental and sustainability aspects are fully considered, a Strategic Environment Assessment (SEA) is recommended for the Gobitec/ASG project. An SEA that works within a structured and tiered decision framework will support a more efficient decision-making process. Since the feasibility study has thus far been conducted only at the preliminary level, further research is needed to identify the optimal technology mix in terms of transmission and generation for the ASG. In parallel, ministerial meetings would allow for consensus building and harmonisation of technology standards for regulatory frameworks. The results from these meetings need to be shared internally within the governments of participating countries.

CONCLUDING REMARKS

Wind turbines on the prairie of Inner Mongolia
Photo: Shutterstock

05

Mongolia is at a crossroad. After a few years of rapid economic growth, the increasing concerns over degradation of local environmental quality are triggering discussions on how Mongolia can strike a balance between short-term economic growth and long-term green development goals. In the Green Development Policy approved by the Mongolian parliament and the State Energy Policy, passed by parliament and published in 2015, renewable energy targets have been set; *i.e.* a 20% reduction of GHG emissions from the energy sector by 2020 and increasing the share of renewables in energy production to 20% by 2023, and 30% by 2030.

With these strategic policy proposals in mind, there has been a call to review and amend the Renewable Energy Law to push for further development of renewables in Mongolia. Proposed changes were made by the MoE and a further study proposal was made by MEGD in collaboration with the UNFCCC.

The study found that reaching the targets and developing Mongolia into a regional clean energy producer and exporter are possible, but challenging. There is a need to look at the issues from a systems perspective. Although renewables are not new to Mongolia, handling the scaling up of renewable energy applications is new to the country's grid operators and energy planners. In the past, renewables have been small-scale such as solar home systems.

Institutional and human capacities should be improved first. Without the relevant renewable energy professionals possessing state-of-art knowledge, Mongolia would have difficulty realising its ambitious strategic goal of becoming the regional clean energy provider. In order to promote further deployment of renewables in the country, the NREC ought to be strengthened through restructuring and reorganisation. A national state-owned research and development (R&D) and training facility funded by the government needs to be established to perform not only further R&D in renewables, but also to support to policy makers in regulatory, policy and legal framework design, technological and technical development and adaptation. It can also provide hands-on experience to graduates, aiding in the development of important human capital. Additionally, the training facility could offer Mongolia's dispatch centres training sessions on how to deal with grid-connected variable renewables.

Physical power system enhancement is critical for grid integration of renewable power generators. Without the power grid infrastructure assessment, it would be difficult to know how much and where variable renewables can be accommodated by the grid. In general, the Mongolian system needs to increase its flexibility. But how much depends on grid status, as improvements cost money. Grid assessments focusing on grid stability should be conducted. Based on their results, distributed generation systems can be installed to stabilise the grid. This will also help set up a legal regulatory framework for roof-top (net metering) units, integration code, and technical standards, and support the provision of financial and economic incentives.

Mongolia has much more renewable energy potential than is required by its domestic consumers, which is why a regional market should be examined. With the demand of clean energy from neighbouring countries such as China, Mongolia is well positioned to provide renewable electricity through a jointly built regional grid infrastructure.However, further feasibility studies need to be done, with the involvement and support of the relevant countries and collaboration from regional and international organisations. A joint force is needed to set such a huge initiative into motion. Gobitec and ASG implementation will require high-level government commitment and intergovernmental negotiations, first to eliminate physical, trade and regulatory barriers, and further to ensure the creation of a viable electricity market in the region. A high-level intergovernmental agreement would be an important first step towards meeting the goals of the ASG to build a regional electricity network for northeast Asia, which can support the increased share of renewables.

Lastly, since there are many people still living in rural areas across Mongolia, a significant portion of which are likely remain there in the coming years as they follow the lifestyle of nomadic herders, rural electricity remains an important need in Mongolia. Upscaling solar home systems from the existing standard 50 W to 500 W or more is a likely next step. Configuring mini-grids with solar and wind for community and productive use is also critical. Mini-grids should be launched in rural areas and can be used for small and medium enterprises as well as agricultural operations. The total capacity of mini-grids can be shared among the users, thus leading to lower cost per user compared to the SHS model.

All in all, given Mongolia's huge renewable energy sources and its strategic vision for green growth, the development of renewables would be a highly strategic move for the country. With current market and development barriers removed, the potential of renewables can be unlocked and provide vast benefits to the country and wider region.

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