Mongolia

Renewable Energy Report

APCTT-UNESCAP

Asian and Pacific Centre for Transfer of Technology
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Abbreviations

ADB	Asian Development Bank
Aimag	Administration unit of Mongolia comparable to province
CES	Central Energy System
CRETG	Central Region Electricity Transmission Grid Co.
DANIDO	Danish International Development Organization
EA	Energy Authority
EES	Eastern Energy System
FEA	Fuel and Energy Authority
Gencos	Generating companies
GTZ	German Technical Cooperation Agency
JICA	Japanese International Cooperation Agency
Khoroo	Administration unit of Mongolia
MFE	Ministry of Fuel and Energy
MME	Ministry of Mineral Resources and Energy
MoF	Ministry of Finance
MoI	Ministry of Infrastructure
NEDO	New Energy Development Organization
NF	Neitherland's Fund
NREC	National Renewable Energy Center
NREL	National Renewable Energy Laboratory
NSOM	National Statistical Office of Mongolia
PTA	Post and Telecommunications Authority
REC	Renewable Energy Corporation
Soum	Administration unit of Mongolia comparable to county
UNDP	United Nations Development Program
USAID	United States Agency for International Development
WB	World Bank
WES	Western Energy System

Executive summary

Mongolia is a relatively large sparsely populated land locked country, sharing borders with the Russian Federation and China. Mongolia's population was estimated in 2007 at 2,635 million people, an increase of 1.3% compared to 2006. The climate of Mongolia is harsh continental. Mongolia is divided into 21 aimags and the capital Ulaanbaatar, which are further divided in 331 soums, 9 districts and 1670 bags and khoroos.

Estimated Mongolia's national CO_2 emission for 1990 was 19.1 million tons or roughly 7.9 tons per-capita. This is mainly due to the energy sector which is dominated by wood and coal and the low energy content of Mongolian coal.

Mongolia's production capacity in 2007 comprises 7 thermal power plants (828.3 MW), 13 hydroelectric power plants (27.5 MW), hundreds of diesel generators (46 MW), 20 wind power plants, solar power plants and a hybrid solar/wind power plant (2.2 MW). In 2007, Mongolia generated 3.700 GWh, imported 195.4 GWh from Russia and exported 10 GWh to other countries. The industrial sector is the largest consumer of electricity, accounting for about 53% of the total distributed energy. The residential sector is the second largest consumer at 21%, followed by transport (4%), agriculture (1%) and others (7%). Grid losses accounted for 13%.

Depending on the region solar, wind and hydro power can be used for power generation. In most areas, renewable energies are even optimal because of the low demand and lack of other energy sources. Mostly concentrated in Western Mongolia, hydropower resources are having high priority in all sector development perspectives. More than 1GW of technical potential of hydropower has been identified. Solar Energy use has mainly focused on decentralized individual solar home electricity system. Gobi region, with higher solar energy resources would be suitable for larger scale solar energy applications. Small solar home systems can be used almost all over the country. According to wind energy resource atlas of Mongolia, more than 160,000km^2 of the land area in Mongolia has been estimated to have good-to-excellent wind potential for utility-scale applications and could support over 1,100,000 MW of installed capacity, and potentially deliver over 2.5 trillion kilowatt-hours (kWh) per year. From the geo-tectonic point of view, Mongolia is part of a consolidated plate and thus not very active. Past experiences for biogas production have failed because of insufficient temperature level in digester during the winter.

Renewable energy (hydro, solar and wind) represents about 3% of country's total electricity generating capacity. Depending on the technology, application and site, costs of renewable energy applications are generally not competitive (except HPP) with grid/retail electricity or commercial heat/energy production. Its role in grid connected electricity supply is currently negligible but through the new feed-in law the role of renewable energy is expected to increase. Although renewable are already in use in the country, their potential remains largely unexploited.

In recent years, the Parliament of Mongolia adopted several important legislations and national programmes for the promotion of renewable energy resources utilization. In this regard, the Energy Law settles to transfer the energy system into market principles, creates independent regulatory mechanism, conditions the private sector participation to the energy system and creates legal environment for promoting competition in the sector. The Renewable Energy Law settles to regulate generation and supply of energy utilizing renewable energy sources. Energy Regulatory Authority of Mongolia is obliged to approve model of power purchase/sales agreement based on feed-in tariff for renewable energy generation. The National Renewable Energy Program targeted to support renewable energy development in Mongolia. The program targeted to increase the share of renewable energy in total energy production by supporting construction of renewable energy power sources in two stages. In first stage (2005-2010 near term) the country should reach 3-5 percent share of renewable energy in total energy production and 20-25 percent in second stage (2011-2020 midterm).

Renewable energy so far plays an important role in two distinct areas: stand-alone home renewable energy systems to provide electricity for nomadic households and off-grid village renewable energy systems to provide electricity for rural centers. Role of renewable energy in grid connected electricity supply is currently negligible but through the new feed-in mechanism set by the Renewable Energy Law, role of on-grid renewable energy is expected to increase.

Strategy for further development of renewable energy technologies in Mongolia consists of: Selecting appropriate renewable energy technologies suitable for Mongolian specific conditions; Commercializing renewable energy technologies; and grid integration of renewable energy applications.

Main sources of problems facing renewable energy development in Mongolia are: Lack of finance and lack of management; Lack of knowledge for developing system configurations and selecting system components; Shortage of domestic private companies specialized in renewable energy; Lack of effort for using energy efficiently; Disregarding international standards; Lack of technical monitoring during installation and lack of performance test evaluation; and Lack of training of operators and capacity building. It is being very important to solve the problems and build up a store of knowledge and experience that will be necessary for further developing RETs. Developing original system configuration of Mongolia will be important in order to promote the installation of renewable energy systems in the future. There is a need to take the initiative of that approach and nurture domestic private companies. The renewable energy system development should be raised as a new domestic industry in order to promote the renewable energy in Mongolia.

Introduction

Mongolia is a relatively large sparsely populated land locked country, sharing borders with the Russian Federation and China. It has a land area of 1.56 million square kilometres and located in Northeast Asia between the latitudes of 41°35'N and 52°09'N and the longitude of 87°44'E and 119°56'E.

Mongolia's population was estimated in 2007 at 2,635 million people, an increase of 1.3% compared to 2006. Its population density varies from 0.70 people/km² in the East to 1.45 people/km² in the Khangai region and 219.4 people/km² in Ulaanbaatar. The urban population was 1,601 million (60.8%) but households' distribution is 59.1% in urban areas and 40.9% in rural areas. Average Mongolian household had in average 4.1 people.

The climate of Mongolia is harsh continental. It is a mountainous country with an average elevation of 1580 m above sea level. The highest peak is the 4374 m in far west and the lowest point is 560 m in the East. Precipitation is unequally distributed both temporally and geographically. The majority of the precipitation (65-80%) occurs in a three month (June-August) period during the summer. The northern regions of Mongolia receive most of the precipitation (400 mm yr^{-1}) while in the southern semi-arid and desert conditions are experienced with less than 50 mm yr^{-1}. Average temperature in most of the country is below the freezing point from November to March and close to it in April and October. Winter nights of -40°C occur most years while summer extremes reach as high as +40°C in the Gobi Desert and +33°C in Ulaanbaatar.

Mongolia is divided into 21 aimags and the capital Ulaanbaatar, which are further divided in 331 soums, 9 districts and 1670 bags and khoroos.

Estimated Mongolia's national CO_2 emission for 1990 was 19.1 million tons or roughly 7.9 tons per-capita. This is mainly due to the energy sector which is dominated by wood and coal and the low energy content of Mongolian coal (10.4-14.6 MJ/kg for lignite and 21.2 MJ/kg for bituminous coal). This estimate is greater than the per-capita rates for Southeast Asia (excluding Bangladesh and Malaysia), Africa, and exceeds the world average. Using current estimates of population growth, Mongolia may experience a three-fold increase in energy demand by the year 2020.

Brief introduction to energy sector of Mongolia

Electricity

Mongolia's production capacity in 2007 comprises 7 thermal power plants (828.3 MW), 13 hydroelectric power plants (27.5 MW), hundreds of diesel generators (46 MW), 20 wind power plants, solar power plants and a hybrid solar/wind power plant (2.2 MW).

As Shown in Figure 1, Mongolia's electricity supply is based on:

- the Central Energy System (CES) supplying Ulaanbaatar, Erdenet, Darkhan, Baganuur, 13 aimag centres and the majority of soum centres;
- the Western Energy System (WES) using imported electricity from Russia to supply 3 aimag centres and their soum centres;
- the Eastern Energy System (EES) powered by 2 thermal power stations,;
- Hundreds of decentralized diesel plants with capacity ranging from 60 to 1000 kW, supplying 2 non connected aimags and some soums;
- Electricity generators used by approximately 50,000 herder families in rural areas.

Five electricity generating companies (gencos), one transmission company, and four distribution companies are operating in the CES. The gencos have 782 MW of installed capacity. Power Plant 4, located in Ulaanbaatar, is the dominant plant with 69 percent of the installed capacity, while Power Plant

3, Darkhan, Erdenet, and Power Plant 2, have 17, 6, 5, and 3 percent of the installed capacity, respectively.

CES and WES are connected to the Russian power grid. The transmission company, Central Region Electricity Transmission Grid (CRETG), has 1,703 km in 220 kV, 2,653 km of 110 kV lines, and 4,298 km in 35 kV. The Darkhan electricity distribution company is owned by the local private sector, and the government is the owner of the remaining companies in the heating and electricity sector.

In 2007, Mongolia generated 3.700 GWh, imported 195.4 GWh from Russia and exported 10 GWh to other countries. The industrial sector is the largest consumer of electricity, accounting for about 53% of the total distributed energy. The residential sector is the second largest consumer at 21%, followed by transport (4%), agriculture (1%) and others (7%). Grid losses accounted for 13%.

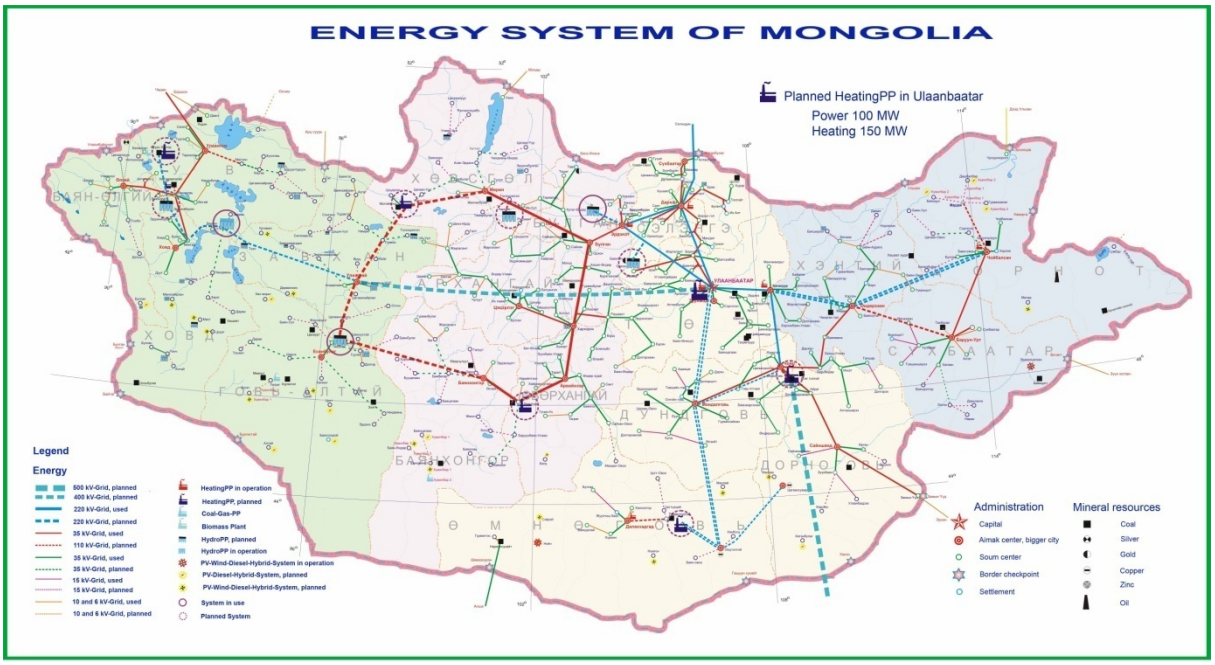

Figure 1: Map of Mongolian power systems

As far as rural electrification is concerned, 227 out of the total 331 soum centres and settlements in Mongolia were connected to power systems in 2008, 87 isolated soum centres supplied by decentralized diesel systems and 8 are powered by renewable energy sources. According to the Ministry of energy, the last 9 soums centres will be supplied in 2009 in the framework of a World Bank project.

The erection of 7000 km new transmission line is planned and tying massive investments. During 2007-2008, 245km of 110kV, 1807km of 35kV, 2967km of 15kV, 342km of 10kV, and total length of 5361km transmission lines are launched for construction and are in the process of commissioning.

Average households monthly electricity consumption amounts to approximately 117 kWh per month in urban areas and 76 kWh per month in rural areas. Households use electricity mostly for lighting in rural areas while in urban areas, appliances, space heating and cooking could be supplementary sources of electricity consumption.

Heat

Due to its latitude and high elevation, Mongolia's average temperatures are quite low, 2 to 4°C in the south-eastern part of the country and -7 to -5°C in the northwest. The average temperature in January is -

20°C falling well below -50°C in unfavourable areas. Therefore, Mongolia is highly dependent on heating systems. Current heat supply can be described as follows:

- District heating systems in the urban centres of Ulaanbaatar and 3 major cities supplying around 30% of the population, based on heat recovered from the 4 CHPs listed above;
- Decentralized medium- and small-sized heating boilers (approximately 2500 HOB[1] with capacity ranging from 0.8 to 2.1 MWth) supplying, around 10% of the population;
- About 60% of the population using individual small heating stoves also used for cooking fuelled by coal in urban areas or wood and dried dung in rural areas.

The total installed heating capacity is approximately 2,273 MWth distributed as follows:

- District Heating in Ulaanbaatar: 1,523 MWth
- District Heating in Darkhan: 210 MWth
- District Heating in Erdenet : 140 MWth
- District Heating in 11 other cities: 13 to 86 MWth

The gross heat generation in 2007 amounted 32,281 GJ while the net distributed thermal energy consumption was 30,467 GJ, out of which households and industries have accounted for 46% and 28% respectively.

Background of development and utilization of renewable energy in Mongolia

Depending on the region solar, wind and hydro power can be used for power generation. In most areas, renewable energies are even optimal because of the low demand and lack of other energy sources.

Mostly concentrated in Western Mongolia, hydro power sites with capacity ranging from 100 kW to 300 MW have undergone pre-feasibility studies and hydropower resources are having high priority in all sector development perspectives. Consideration is being given to further develop small hydro plants in order to reduce diesel imports. A number of hydro power stations with capacities ranging from 100 kW up to 220MW (Orkhon HPP 100MW, Egiin Gol HPP 220MW, Chargait HPP 24MW, etc.) have been studied for feasibility during the last few years for both grid – supportive for voltage control- and off-grid supply. One complicating factor is that many rivers freeze-over during the winter and cannot provide year-round electricity.

[1] World bank report : Mongolia Energy, Annex I

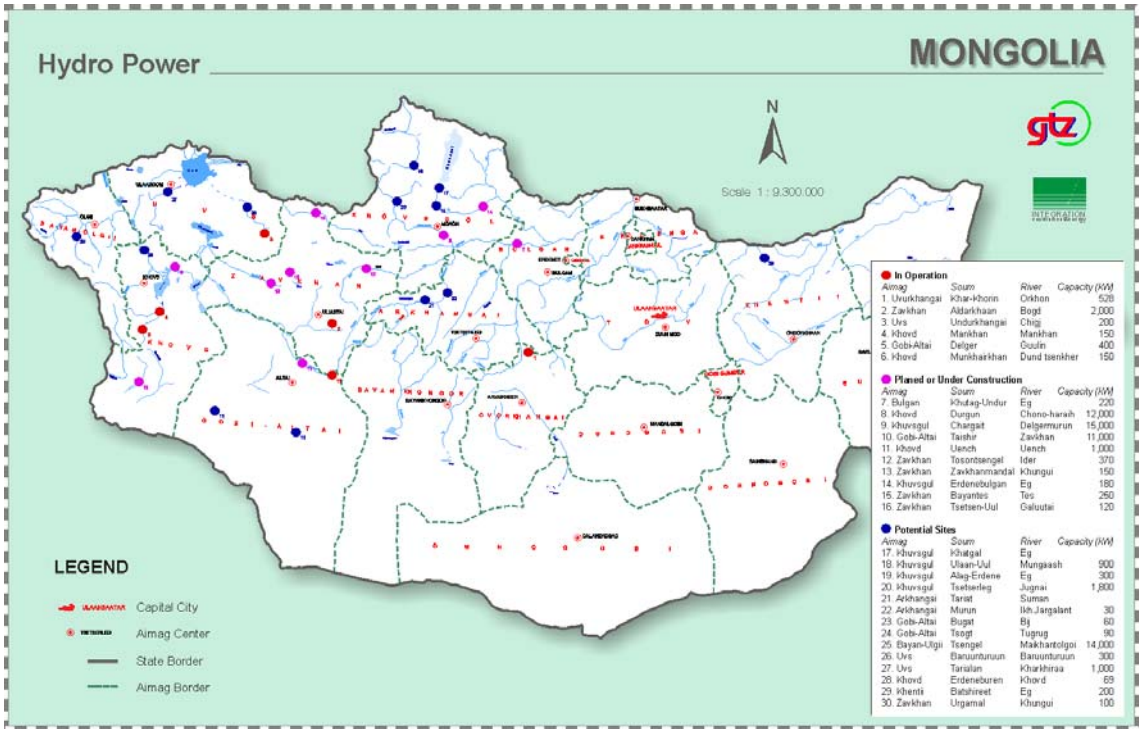

Figure 2: Map of Installed and Planned Hydro Power Plants in Mongolia, *Source: GTZ/INTEGRATION, 2007*

Solar Energy use has mainly focused on decentralized individual solar home electricity system. Government supported “100000 Solar Ger” program has supplied 72,000 PV home systems with capacity of 20-50W to nomadic families. During last few years, 97 secondary schools in soum centers were supplied with 100W PV systems. 200kW PV system in Noyon soum, Umnugovi aimag which is the biggest, is in operation. A number of PV systems (20-100kW) and PV-wind hybrid systems (30kW PV) are in operation, over the country. Gobi region, with higher solar energy resources would be suitable for larger scale solar energy applications. Small solar home systems can be used almost all over the country.

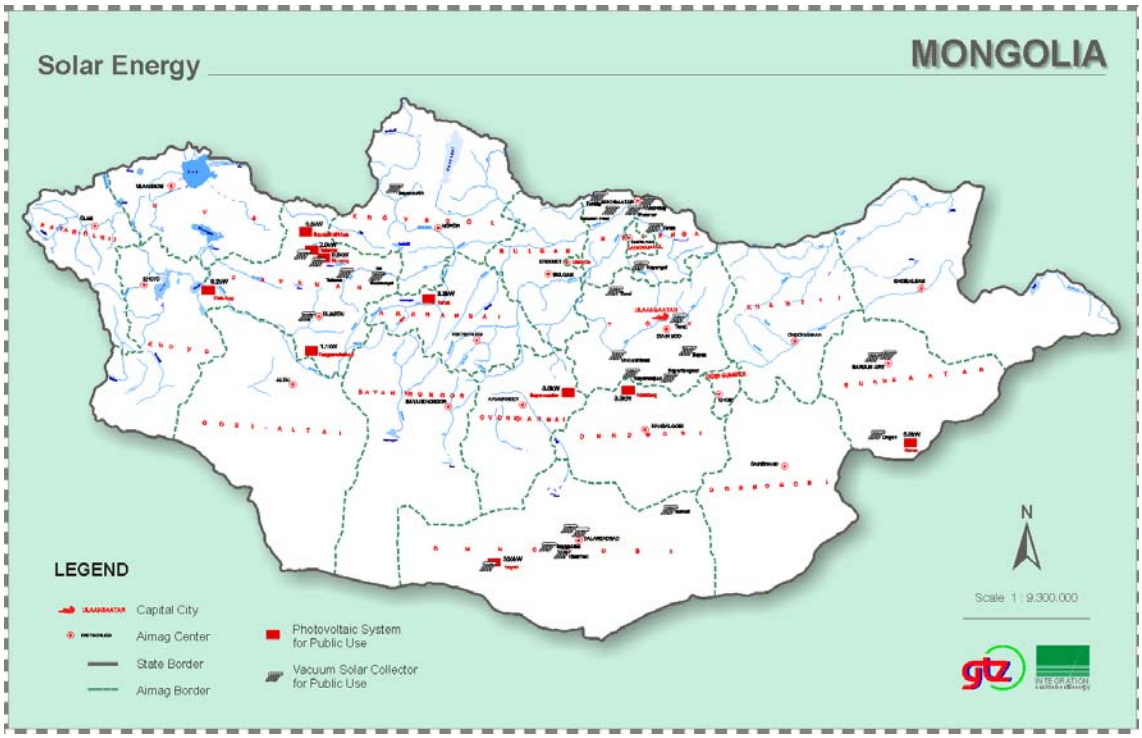

Figure 3: Utilization of solar potentials, Source: GTZ/INTEGRATION, 2007

Current installed capacity of wind turbines sums up to 1,450kW. 100kW wind turbine, which is currently the biggest, was installed in Erdenetsgaan soum, Sukhbaatar aimag. A number of wind power systems (70-150kW) and wind-solar hybrid systems (120kW wind) are in operation, over the country. 50MW on-grid Wind Park near Ulaanbaatar is underway and power purchase agreement was made.

According to the study of the Energy Research Institute, larger scale wind turbine generators with capacity of 100-150 KW could be placed in 52 provincial centers in the southern part of Mongolia. The most promising sites should get priority for establishing the technical and economic feasibility of operating 100-150 kW wind turbine generators in parallel with existing diesel generators. This system will include battery - inverter storage systems to enable the diesel generators to back-up wind turbines.

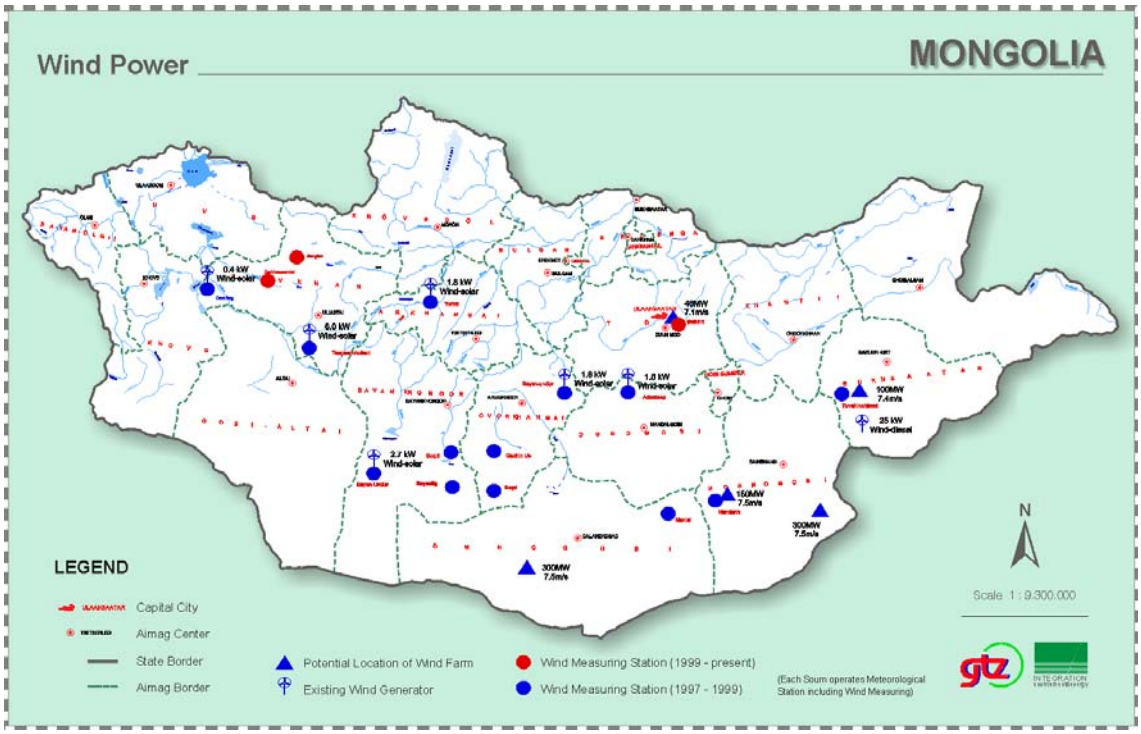

Figure 4: Utilization of Wind Potentials, Source: GTZ/INTEGRATION, 2007

Mongolia has 42 hot springs. Some of the hot springs is used for traditional health resorts and small-scaled greenhouse/space heating only. Based on the available information the commercial exploitation of geothermal resources in Mongolia for power generation is still considered marginal. Further investigations will be required to verify the extent of geothermal resources and their potential of utilization for small-scale power generation possibly with binary cycle power plants.

Renewable energy resources of Mongolia

Hydropower resources

There are about 3800 small rivers with a total length of 65 thousand km in Mongolia. The average annual flow is $3.46*10^{10}$ m^3 and the physical hydro energy potential is estimated at 6200 MW. Hydropower resources of Mongolia have not been fully investigated yet. However, a number of promising hydropower sites has been identified to date in Mongolia. According to the study of NREC, about 70 % of all hydro energy resources are concentrated in the Mongolian Altai ranges, in the Tagna and Khan Khukhii ranges, in the mountainous areas of Khuvsgul, Khangai, Khentii and Khalkh Gol River. More than 1GW of technical potential of hydropower has been identified.

Hydro power potentials, planned and installed capacities in Mongolia can be found in Figure 5.

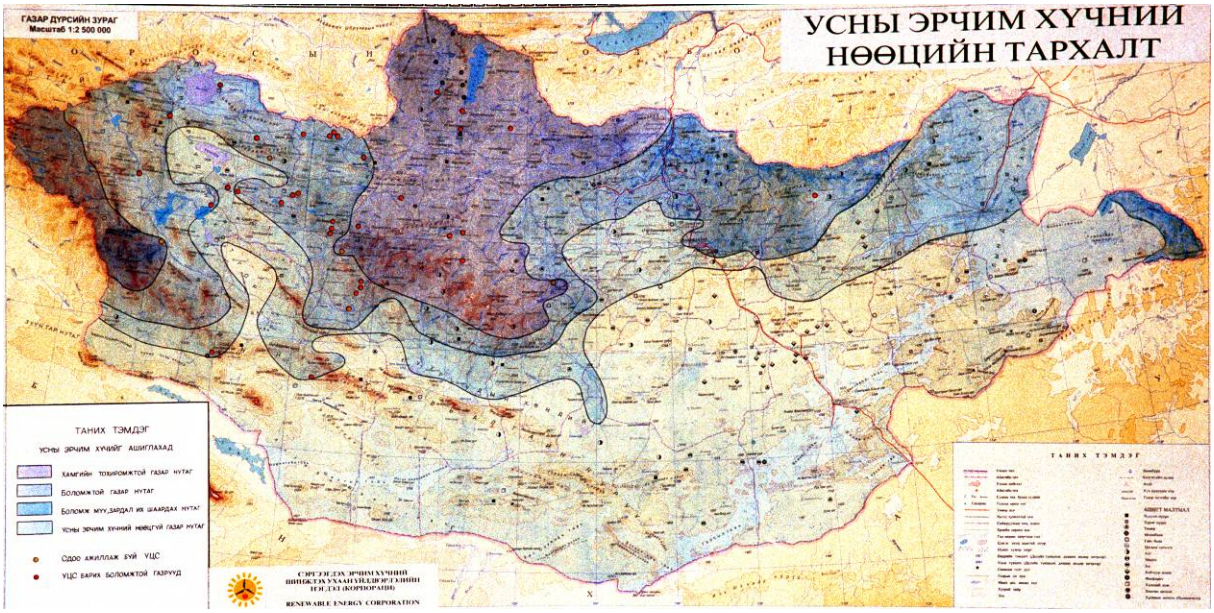

Figure 5: Hydro energy resource map of Mongolia

Solar energy resources

Mongolia enjoys a favorable solar energy regime, ranging from a low insulation of 4.5 kWh/m^2 per day and less than 2600 sunshine hours in the northern part of the country, to a high of 5.5-6.0 kWh/m^2 per day with a sunshine duration of 2900-3000 hours in the southern part of the country. The high insulation regime covers some 70% of the territory. Intermediate insulation of 4.5 – 5.5 kWh/m^2 per day with an annual sunshine duration of 2600-2900 hours covers 18% of the territory of Mongolia. It is estimated that the southern part of the country receives a daily average insulation between 4.3 and 4.7 kWh/m^2/day. Total annual radiation intensity equals to 2.2*10^{12} MWh in Mongolia. However, the current information available is not considered to be sufficiently accurate or complete for solar energy system design purposes. Solar energy resource map of Mongolia is shown in Figure 6.

Figure 6: Solar energy resource map of Mongolia

Wind energy resources

Recently, a wind energy resource atlas of Mongolia has been developed with the assistance of the National Renewable Energy Laboratory (NREL) of the Department of Energy, USA.[2] According to this atlas, more than 160,000km^2 of the land area in Mongolia has been estimated to have good-to-excellent wind potential for utility-scale applications. The amount of windy land is about 10% of the total land area of the country. This amount of windy land, using conservative assumptions that result in about 7 megawatts (MW) of capacity per km^2, could support over 1,100,000 MW of installed capacity, and potentially deliver over 2.5 trillion kilowatt-hours (kWh) per year.

All of the aimags have at least 6,000 MW of wind potential. There are in Mongolia 13 aimags that have at least 20,000 MW of wind potential, and 9 aimags that have greater than 50,000 MW of potential. Umnugovi alone is estimated to have over 300,000 MW of potential. If additional areas with moderate wind resource potential (or good wind resources for rural power applications) are considered, the estimated total windy land area increases to more than 620,000 km^2, or almost 40% of the total land area of Mongolia. This amount of windy land could support over 4,300,000 MW of installed capacity and potentially deliver over 8 trillion kWh per year. There are 15 aimags with at least 50,000 MW, 12 aimags with at least 100,000 MW, and 9 aimags with at least 200,000 MW of wind potential. These data show that wind could play an important role in the development of both rural areas (individual wind generators) and small urban centers (Soum, or even Aimag). Utility scale wind resources at 30 m height are shown in Table 1 and Table 2. Wind resource map of Mongolia is shown in Figure 7.

Table 1: Good-to-Excellent Wind Resource at 30m (Utility scale)

Wind Class	Wind Power at 30m (W/m^2)	Wind Speed at 30m (m/s)	Total Area (km^2)	Percent of Windy Land	Total Capacity Installed (MW)	Total Power (GWh/yr)
3	300-400	6.4-7.1	130,665	81.3	905,500	1,975,500
4	400-600	7.1-8.1	27,165	16.9	188,300	511,000
5	600-800	8.1-8.9	2,669	1.7	18,500	60,200
6	800-1000	8.9-9.6	142	0.1	1,000	3,400
Total			160,641	100.0	1,113,300	2,550,100

Table 2: Moderate-to-Excellent Wind Resource at 30m (Utility scale)

Wind Class	Wind Power at 30m (W/m^2)	Wind Speed at 30m (m/s)	Total Area (km^2)	Percent of Windy Land	Total Capacity Installed (MW)	Total Power (GWh/yr)
2	200-300	5.6-6.4	461,791	74.2	3,200,200	5,572,900
3	300-400	6.4-7.1	130,665	21.0	905,500	1,975,500
4	400-600	7.1-8.1	27,165	4.4	188,300	511,000
5	600-800	8.1-8.9	2,669	0.4	18,500	60,200
6	800-1000	8.9-9.6	142	0.0	1,000	3,400
Total			622,432	100.0	4,313,500	8,123,000

[2] Atlas of Wind Energy Resource in Mongolia. USAID, NREL and NREC. 2000

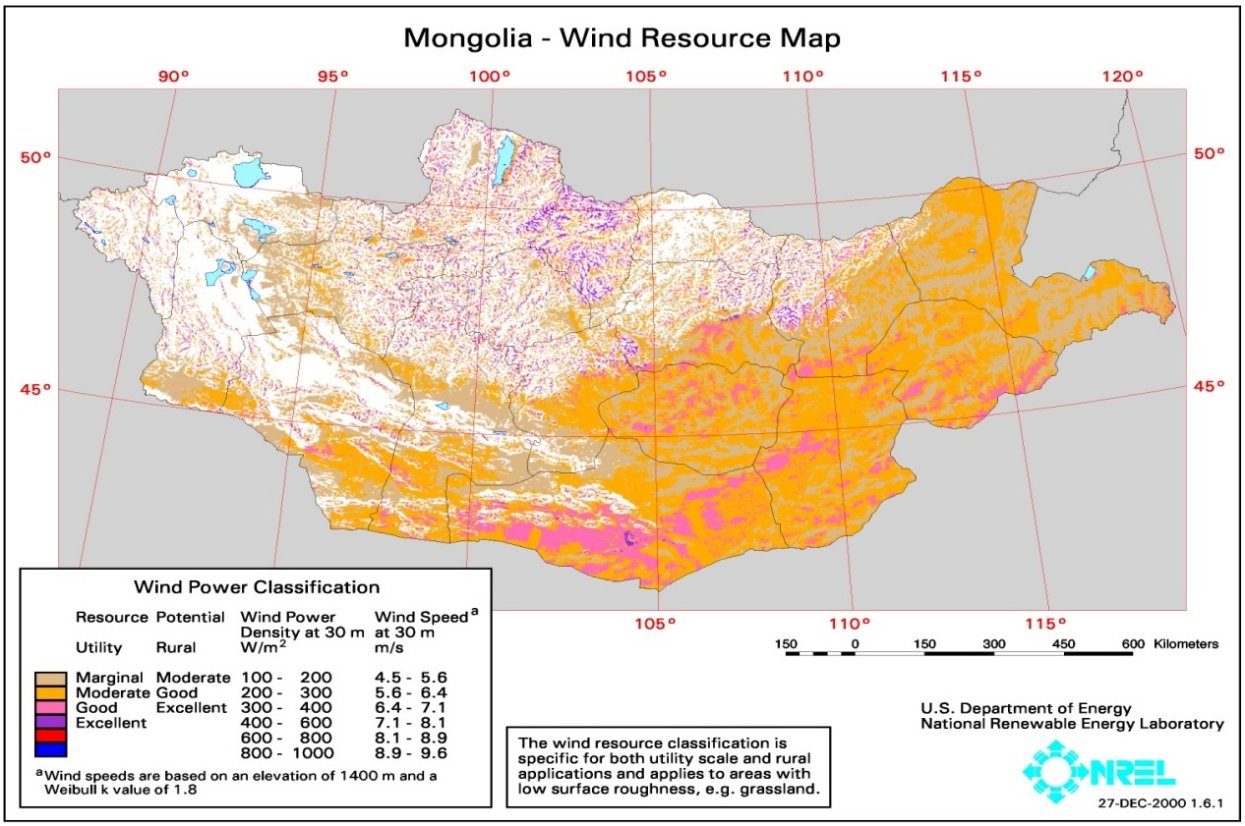

Figure 7: Wind energy resource map of Mongolia

Geothermal energy resources

From the geo-tectonic point of view, Mongolia is part of a consolidated plate and thus not very active. An exception is an east-west stretch in the northern part of the country where horizontal movement of two plates temporarily results in earth quakes. Along this area a number of hot springs occur. Mongolia has about 42 small hot springs in Khangai, Khentii, Khuvsgul, Mongolian Altai mountains, Dornod-Darigangiin steppe and Orhon-Selenge region.

An overall estimation of the technical/physical/economic geothermal energy potential is not available. However a geophysical survey on the crustal structure affirmed that accumulative thermal sources (magma lumps) are located near the surface under the Khangai and Khentii mountainous region. Heat flow in Mongolia was studied from 32 heat flow stations. However, the heat flow map does not cover the South Mongolia and the Mongolian Altai province, where information is scarce. The average heat flow in different tectonic regions is approximately estimated as follows: Mongolian Altai mountainous region: 54±24 mW/m^2, Khangai mountainous region: 52±6 mW/m^2, Khuvsgul lake region: 80±10 mW/m^2, East Mongolian steppes: 44±6 mW/m^2. Outlines of the main geothermal structures of Mongolia are shown in Table 3. Heat flow map of Mongolia and is shown in Figure 8.

Table 3: Outlines of the main geothermal structures of Mongolia

	System	Subsystem	Blockage	Heat flow (kcal/cm^2)	Geothermal gradient (°C/km)	Chemical composition	Minerals (g/l)
Fold platform zone	Khangai	Tarvagatai-Uliastai Baidrag-Taishir Orkhon-Taats	open, semi-open	1.8-2.4	45-80	SO_4, HCO_3/Na, CO_3 HCO_3, CO_3/Na, SO_4	<0.5
	Khentii	Khoid Khentii Onon-Ulz	semi-open closed	1.0-1.2	35-50	HCO_3, CO_3/Na, SO_4 SO_4, HCO_3/Na	<1.0
	Khuvsgul	Nuur Murun	semi-closed closed	0.8-1.2	25-40	SO_4, HCO_3/Na	<1.0
	Bulnai	Bulnai	open	0.7-1.0	20-25	SO_4, HCO_3/Na, CO_3	<0.5
	Altai	Altai Ikh Bogd	semi-closed closed	1	20-30	SO_4/Na, HCO_3	1-5
Transitional zone	Transitional	Mongol-Daur Bayankhongor Bulgan Sant Zaamar	closed	1	20-35	SO_4Cl/Na	3-10
Subsided zone	Dornod-Dariganga	Dornod Dariganga				$ClSO_4$/NaCa	5-25 (150)
	Gobi	Sainshand Gobi	closed	1	20-35	$ClSO_4$/Na	20-80 (300)
	Ikh Nuur	Nuur				$ClSO_4$/Na	15-66 (120)
	Orkhon-Selenge	Orkhon-Selenge				$ClSO_4$/NaMg	10-20

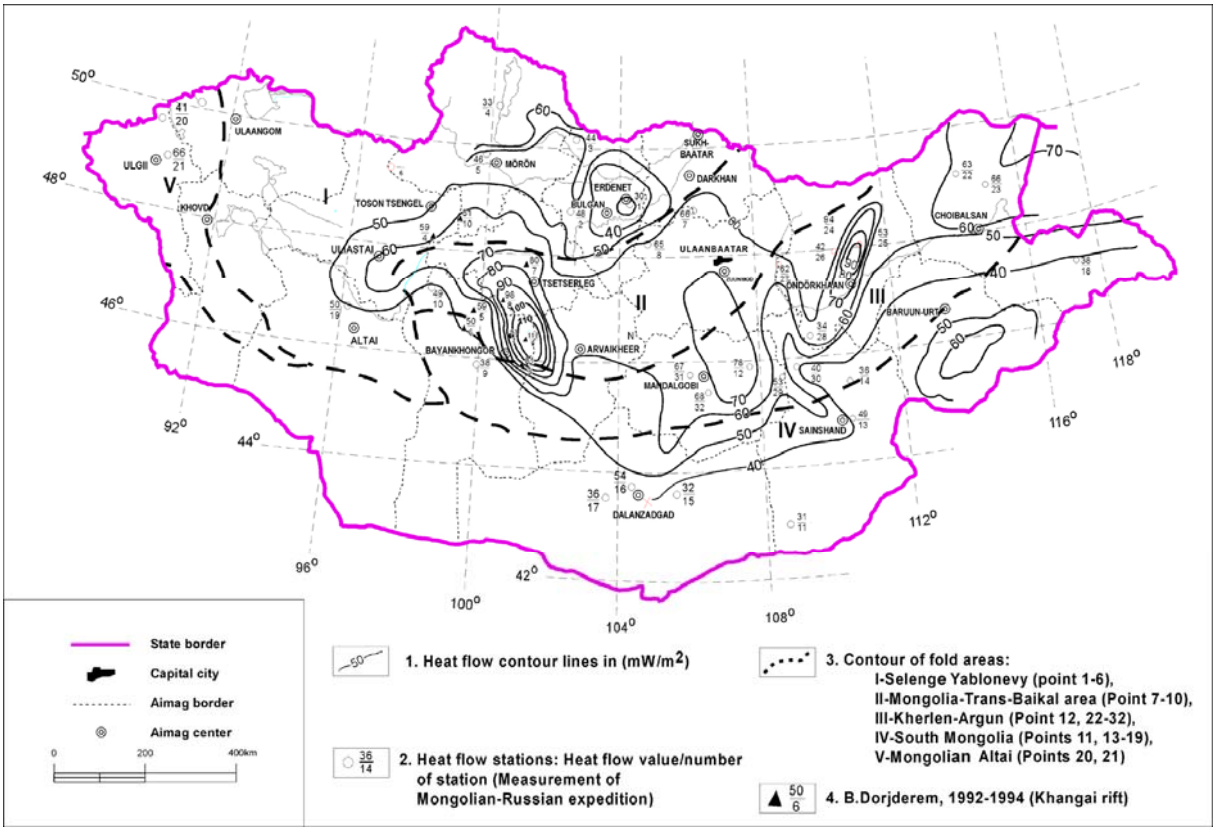

Figure 8: Heat flow map of Mongolia

Biofuels

Traditional biomass (firewood, animal dung and agricultural residues) is still the main energy resource for rural areas and especially for nomadic households. However, utilization of biomass for biogas production and energy generation is limited.

Biomass from livestock: includes dried cow dung, sheep and goat pellets, horse-dung, hardened dung and urine of sheep, and camel dung. Horse and camel dung will not be considered in this evaluation because collection is difficult since these animals moved far from the herder houses. In 2003, the annual biomass production was ranged between 5,874 and 6,645 megatons, with an energy content of 82 TJ. The available biomass is calculated on the basis that a cow, a sheep and a goat generates respectively 3 kg, 0.6 and 0.4 kg of dung. Based on the life style of herder families according to which animals are released in the morning and come back in the fences in the evening, it was considered that the collectable dung in the fences equals one third of the production, 1.96 to 2.21 megatons. Based on the assumptions above, the minimal available dung potential for energy purposes in 2008 would be about 3 Megatons, equivalent to a primary energy potential of 75,000 TJ[3].

Forest residues: The two primary categories of forested land are northern coniferous forests and southern Saxaul forests. Commercial and domestic exploitation of forest resources is primarily for timber and firewood. Timber comes exclusively from the northern forests, while both northern and southern forests serve local needs for firewood, livestock forage, and other non-forest timber products. The average standing volume of northern closed forest is estimated to 103 m^3 per hectare, for a total standing volume in excess of 1,300 million m^3.

Reliable statistics on actual exploitation are missing with many reports citing substantial levels of illegal harvest. Official statistics underestimate total industrial output by failing to account for these numbers. The same statistics also do not record the 2.5 million m^3 annual consumption of firewood or other household-use wood. The last national forest inventory was conducted almost 30 years ago with local inventories being carried out on an estimated 20+ year cycle, using methods that have not changed substantially in 50 years. Even if the inventories were adequate to establish appropriate harvest levels, there appears to be no connection between them and the setting of an annual allowable cut. Decisions are made in an ad hoc manner and resources allocated to the strongest lobby.

Statistics on deforestation and forest depletion are confusing and often conflicting, however, it has been estimated (World Bank 2002) that Mongolia lost about 1.6 million hectare of forest from the 1950s to the 1980s, and a further 660,000 hectare from 1990 to 2000. The major causes of forest loss have been unsustainable forest harvesting (both permitted and illegal) for timber and firewood, wildfires, mining, insect and disease infestations, uncontrolled grazing and long-term climatic fluctuations.

[3] Pepin Tchouate, Potential heating energy options for rural settlements and ger dwellers, UNDP report, Ulaanbaatar 2009.

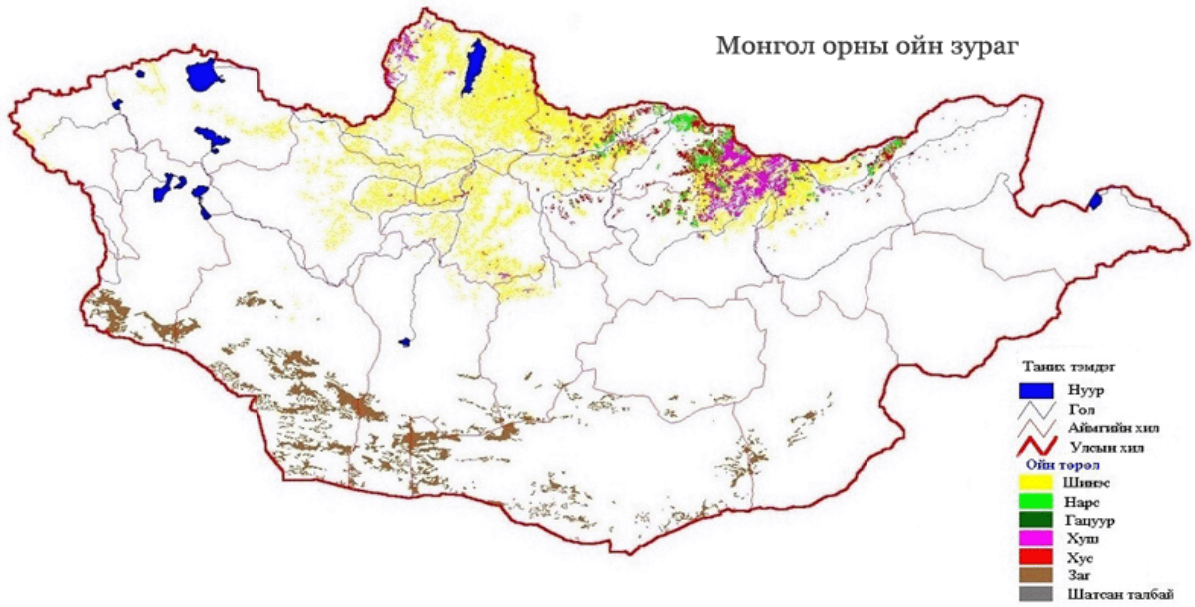

Figure 9: Forest resource map of Mongolia

Agricultural residues: Straw can be considered with an average LHV of 9000-10000 kJ/kg. Based on 1997 data, only 12 aimags are involved in wheat production and the total amount of straw in Mongolia was 254,440 tons, deducted from the total wheat production with the equivalence 1kg of wheat for 2 kg of straw. Preliminary data for 2007 predict a wheat production of 110 ktons (NSOM 2007), meaning available straw could be 220 ktons. Primary energy potential ranges between 198 and 220 GJ. The national program "Cultivation III" launched in 2008 has provided loan to farmers, increasing the wheat production to 200 ktons of wheat, leading to an equivalent primary energy source of about 400 GJ[4].

Biogas production: Past experiences for biogas production have failed because of insufficient temperature level in digester during the winter. Weather and wastes composition in Mongolia are not suitable to develop the biogas from the wastes. Therefore, there are no proper technologies for producing biogas by landfill and waste combustion power generation technologies.

Some research institutes and private companies are considering possibilities to develop the solid biomass fuels combined with advanced combustion technologies.

Municipal solid waste: (industrial and domestic) generated in Mongolia annually is estimated at approximately 4,000,000 cubic meters. More than 900,000 cubic meters of these are household solid wastes in Ulaanbaatar. All the wastes in settlement areas are simply collected and transported to designated waste dumping sites on the outskirts of the cities. These designated waste dumping sites receive domestic wastes, construction wastes, sewage treatment sludge, boiler ash, industrial wastes, and hospital wastes, which are dumped indiscriminately within the site. A portion of these wastes, particularly in the last two categories, is believed to consist of toxic and hazardous (including radioactive) wastes.

[4] Pepin Tchouate, Potential heating energy options for rural settlements and ger dwellers, UNDP report, Ulaanbaatar 2009.

Fossil energy resources available in the country

Coal

Main energy resource in Mongolia is coal with reserves estimated at about 152 billion tons, of which over 22.3 billion tons have been identified by preliminary and comprehensive geological prospects (Purevsuren and Drebenstedt, 2004)[5]. Out of over 200 coal deposits identified throughout the territory, about 50 deposits have been searched, assessed and explored and 32 deposits are under exploitation. Figure 1 shows main coal basins of Mongolia.

Total coal production in 2007 was 9.24 million tons, of which some 5.91 million tons has been used for energy generation (NSOM, 2007), and 3.27 million tons being exported. Major coal producers are the Baganuur, Shivee Ovoo and Sharyn Gol mines with annual capacities of 2.8 million, 1.2 million and 0.45 thousand tons, respectively. Their production is mainly lignite with heating values ranging from 2,700 to 4,000 kcal/kg, 18–35 percent moisture, and 12–21 percent ash. In addition, small and medium-size mines produce coal of similar quality with a heating value of 5000 kcal/kg and low moisture.

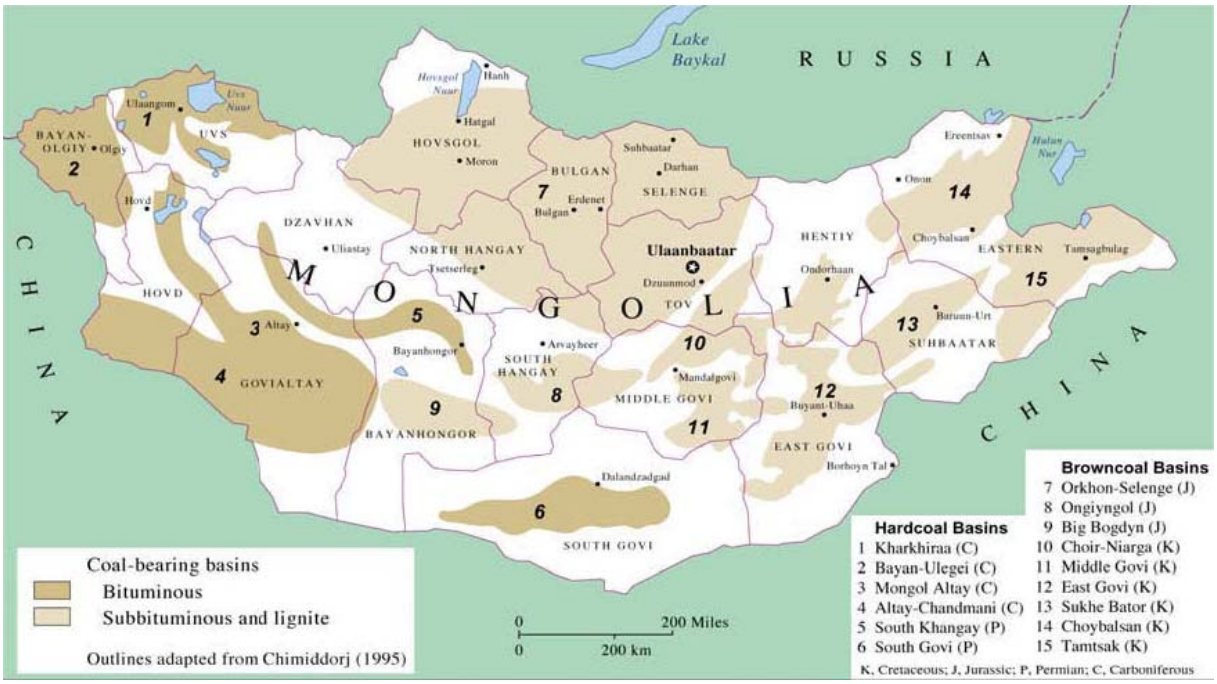

Figure 10: Mongolia's coal basins

Oil

Oil deposits with associated gas have been discovered in the Tamsag Basin with an estimated potential of 4.5 billion barrels. One company is presently conducting oil mining with an annual production of 135,000 barrels of crude oil that is exported to China without refining.

Renewable energy markets and industries scenario in the country

Renewable energy so far plays an important role in two distinct areas: stand-alone electricity supply for nomadic households and off-grid electricity supply for rural centers. Renewable energy (hydro, solar and

[5] Purevsuren and Drebenstedt (2004): Actual aspects of lignite mining in Mongolia, in *Mine Planning and Equipment Selection*, Wroclaw, Poland, 2004.

wind) represents about 3% of country's total electricity generating capacity. According to recent statistical surveys, 103,000 nomadic households light their homes from solar PV modules (20-200W) and/or small wind generators (50-300W). Biomass (firewood) is largely used for heating and cooking. Biogas production is limited due to the climatic conditions and the lack of sufficient quantities of feces. Several off-grid small/micro HPPs supply electricity to neighboring rural centers. A number of stand-alone solar-wind-diesel hybrid systems (or various combinations of them) with capacity of 20-180kW, supply electricity to rural centers. Hot water from natural hot springs is used for greenhouse/space heating in few houses. Vacuum tube solar water heaters with 120-160 l water tanks were installed in about 100 places. A first power purchase agreement was made for 50MW on-grid Wind Park and the project is underway.

Depending on the technology, application and site, costs of renewable energy applications are generally not competitive (except HPP) with grid/retail electricity or commercial heat/energy production. Its role in grid connected electricity supply is currently negligible but through the new feed-in law the role of renewable energy is expected to increase.

Although renewable are already in use in the country, their potential remains largely unexploited. Table 4 below, compares the installed capacity of several RETS to the technical capacity of the whole country. As can be realized from the table below a lot of potential for all RE exists in the country and therefore sustainable methods of disseminating RE should be established. Earlier attempts to disseminate the RE have experienced minimal success due to investments and lack of know-how.

Table 4: Technical potentials for Renewable Energy (MW)

Technology	Installed capacity (MW)	Economic Potential (MW)	Technical Potential (MW)	Physical Potentials (MW)
Solar PV	5.17	n.a.	n.a.	$2.2 * 10^{12}$ (MWh/year)[6]
Solar WH	0.01			
Small hydro	23	n.a.	1000	6200[7]
Mini Hydro	2			
Micro Hydro	2.5	n.a.	n.a.	n.a.
Biogas	none	n.a.	n.a.	n.a.
Wind	1.45	n.a.	4,300,000[8]	n.a.

Low tariffs for conventional energy systems and abundant coal resources constrained the development of renewable energy systems. However recent initiatives of the Government towards the development of renewable energy systems would change the attitude. Mongolia is rich in renewable energy resources. Solar, wind and hydro power can be used for power generation. Due to the absence of a centralized supply system, the low demand and lack of other energy sources, renewable energies are the optimal and (in most areas) the only option for rural electricity supply.

Solar: Solar energy use has mainly focused on decentralized individual solar PV systems. 200kW PV system in Noyon soum, Umnugovi aimag, which is the biggest, is in operation. A number of PV systems (20-100kW) and PV-wind hybrid systems (30kW PV) are in operation, over the country. PV solar home systems are widely used for nomadic supplies. According to statistical surveys, 103,000 nomadic families are using solar PV systems, in 2008. Public services in non-grid soum centers such as telecommunication offices, TV repeater stations, border control units and hospitals use solar PV systems. Vacuum-tube solar water heaters with 120-160L tanks were introduced recently and more than 100 installations are being

[6] ADB, Promotion of renewable energy, energy efficiency and greenhouse gas abatement, 2004.
[7] ADB, Promotion of renewable energy, energy efficiency and greenhouse gas abatement, 2004.
[8] NREL, Atlas of Wind Energy Resource in Mongolia, 2000

used in bathhouses, hospitals and tourist camps. International Energy Agency is currently making a study on very-large scale PV power systems in Gobi region of Mongolia.

The National Renewable Energy Center has a facility for assembling PV modules with capacity of 500 kW_p per year. Since its establishment in 1998, the factory has produced 350 kW_p solar panels and installed 700 kW_p stand-alone PV systems for the telecommunication offices, hospitals and schools in off-grid soum centers, TV repeater stations, as well as PV home systems for nomadic households. Number of companies and private businesses are importing solar home systems mainly from China. As part of donor's assistance projects and Government programs a bunch of solar home systems were supplied to nomadic households and public services in rural areas.

Geothermal: Mongolia has about 42 small hot springs in Khangai, Khentii, Khuvsgul, Mongolian Altai mountains, Dornod-Darigangiin steppe and Orhon-Selenge region. Some of the hot springs is used for traditional health resorts and small-scaled greenhouse/space heating. Based on the available information the commercial exploitation of geothermal resources in Mongolia for power generation is still considered marginal. Further investigations will be required to verify the extent of geothermal resources and their potential of utilization for small-scale power generation possibly with binary cycle power plants.

Small hydropower: Hydro power prevails in the western mountainous region. In recent years, there is increasing interest in constructing larger scale HPPs in order to reduce the imported electricity from Russia. Current policy of Ministry of Mineral Resources and Energy for hydro power is to support grid-connected HPPs to cover peak load of CES. Cascade HPP on Selenge River is also being discussed. Construction of Taishir HPP with capacity of 11 MW was completed in 2008. Govi-Altai aimag center is connected to the HPP with 47 km transmission line of 35kV and Zavkhan aimag center is connected with 135 km transmission line of 110 kV. The project was financed by 20 million USD from Kuwait fund, 13 million USD from Abu-Dhabi Fund and 2.7 million USD from the Government of Mongolia. Construction of Durgun HPP with capacity of 12MW was completed in 2008. The HPP will supply Uvs, Khovd and Bayan-Ulgii aimags with electricity. The project was financed by 26.5 million USD from soft-loan of Shanghai Group of China.

Mini hydropower: Currently, there are 11 mini HPPs with total capacity of 2.5MW in operation. The small hydro plants are run-of-river designs that provide electricity to neighboring rural areas except during the winter. Consideration is being given to further develop small hydro plants in order to reduce diesel imports. A number of hydro power stations have been studied for feasibility during the last few years for both grid and off-grid supply. One complicating factor is that many rivers freeze-over during the winter and cannot provide year-around electricity. In order to prioritize and to better identify the economic potentials, there is a need for developing a hydropower master plan.

Private company, Uliastai Energy Co., LTD is operating Bogdiin HPP and is a pioneering company to operate renewable energy plants.

Wind: Current installed capacity of wind power sums up to 1,450kW. 100kW wind turbine, which is currently the biggest, was installed in Erdenetsgaan soum, Sukhbaatar aimag. A number of wind power systems (70-150kW) and wind-solar hybrid systems (120kW wind) are in operation, over the country. Nomadic households use small wind turbines with capacity 50-400W. 50MW on-grid Wind Park near Ulaanbaatar is underway and power purchase agreement was made. License for construction of the wind-park is issued to NewCom LLC. Germany KfW Bank financed "Renewable Energy II" project is making a study on Wind Park in Gobi region of Mongolia. Wind speed measurement has started in order to access the possibility of constructing Wind Park in Gobi-Altai aimag, which can work parallel to Taishir HPP.

Private company, MonMar Co., LTD. manufactures wind turbines with capacity of 50W. The factory uses a proven technology that was transferred from Marlec Co. of UK. Number of companies, namely, Sobby

Co., LTD. imports Air and Whisper brand-named small wind turbines from SouthWest WindPower Co., LTD. of USA.

Biofuels: Due to the climatic conditions the use of bio-fuels in Mongolia is mainly limited to wood and dung potentials. Firewood and dung is still the main energy resource for rural areas and especially for nomadic households. However, utilization of biomass for energy generation is limited. Commercial and domestic exploitation of forest resources is primarily for timber and firewood.

Biogas production is limited due to the climatic conditions and the lack of sufficient quantities of feces. Weather and wastes composition in Mongolia are not suitable to develop the biogas from the wastes or grow bio fuel plants. Therefore, there are no proper technologies for producing biogas by landfill and waste combustion power generation technologies. However, some research institutes and private companies are considering possibilities to develop the solid biomass fuels combined with advanced combustion technologies.

Leading R&D institutions and national/international agencies in the country working in the area of renewable energy, particularly those working on capacity building and information dissemination and R&D and demonstration programs

Trade Organizations

Name of the organization Contact person	Address Phone number Email contact	Description of products and services, role
Foreign Investment and Foreign Trade Agency Baasankhuu Ganzorig Chairman, WAIPA Steering Committee Member	Tel: + 976-11-326040, 320871, 321438, 320793, Fax: + 976-11-324076 E-mail: fifta@investmongolia.com Post: FIFTA, Sambuu Street 11, Ulaanbaatar 211238, Mongolia Office: Suites 209, 801-805, 1202. Government Building 11, Sambuu Street 11, Ulaanbaatar, Mongolia Web: www.investmongolia.com	Foreign Investment and Foreign Trade Agency of Mongolia (FIFTA) is the government agency responsible for the promotion and facilitation of foreign direct investment and foreign trade in the country. The FIFTA's vision is to promote and facilitate foreign investment and foreign trade towards meeting the national goals of industrial development and export growth, to promote Mongolia as a destination for new investment and business, and to be the leading agency in Mongolia.
Mongolian National Chamber of Commerce and Industry S.Demberel Chairman & CEO	J.Sambuu street-11, Ulaanbaatar-211238, Mongolia Tel: +976-11-327176, 312501, 323974 Fax: +976-11-324620 E-mail: chamber@mongolchamber.mn info@mongolchamber.mn Web: www.mongolchamber.mn	Established in 1960. Since the adoption of the Law of the Chamber of Commerce and Industry in 1995 the Chamber`s activities have been expanding both domestically and internationally. The Chamber is the main business representative body of Mongolian business community engaging the most of companies, enterprises and trade organizations and protecting their common interests.

Financing Institutions

Name of the organization Contact person	Address Phone number Email contact	Description of products and services, role
Golomt Bank	Commercial street -6 UB-36 Mongolia Tel: +976-11-310639, 323844 Fax: +976-11-326865 Web: http://www.golomtbank.com	Golomt Bank of Mongolia declared an after tax profit of MNT 7.96 billion (USD 6.88 million) for the first half of 2008. Total assets reach MNT 724 billion, (USD 625 million).
Khaan Bank	Seoul Street-25, PO.Box-192, Ulaanbaatar-44, Mongolia Tel: 976-11-332-333 Fax: 976-7011-7023 Web: www.khanbank.com	In 2007, after-tax earnings were MNT 19.4 billion. This equated to return on assets of 3.9% and return on equity of 45.9%. Branch system has 466 offices.
Trade and Development Bank of Mongolia	Juulchnii street 7, Baga toiruu 12, Chingeltei district, Ulaanbaatar, Mongolia Tel: +976-11-312362, 331133 Fax: +976-11-327028, 331155 web: http://www.tdbm.mn	In June 2008, TDB's total asset reached MNT 661.5 billion and own capital reached MNT 79 billion, representing 17.2% and 18.7% market shares respectively. The Bank has had earnings track record with MNT 11.8 billion in 2006, 16.4 billion in 2007 and 8 billion in Jun 2008.

Government Agencies

Name of the organization Contact person	Address Phone number Email contact	Description of products and services, role
Energy Authority Mr. Ts.Bayarbaatar Director	Chinggis avenue Khan uul district, 210136 Tel: +976-11-343006 Email: info@ea.energy.mn Web: www.ea.energy.mn	Implementation of project and programs in energy sector. Technical monitoring, general orderer of Government financed project in energy sector. Energy sector research and development.
Energy Regulatory Authority Mr. R.Ganjuur Chairman	Address: University street 2a, Sukhbaatar district, 14201 Tel: +976-11-319312 Email: ganjuur@era.energy.mn	Main regulatory institution in energy sector.
Ministry of Finance Mr. D.Battur State Secretary	United Nations Street 5/1 210646 Tel: +976-11-260247 Email: battur_d@mof.gov.mn	Monitoring, planning and defining policy for financial sector of the country. ..
Ministry of Mineral Resources and Energy Mr. Ts.Tserenpurev State secretary	Government building II, United Nation Street-5/2, 210646 Tel: +976-11-261511 Email: stsec@mme.energy.mn Web: www.mme.energy.mn	Defining, regulation, monitoring, planning of energy sector development policy, organization and implementation of Government programs and project in energy sector.
Ministry of Nature and Environment Mr. T.Gantulga State Secretary	Government building III, Baga toiruu-44, Sukhbaatar district Tel: +976-11-265615 Email: mne@mongol.net	National Designated Authority for CDM. Policy defining, planning, and monitoring in environmental sector of Mongolia
National Renewable Energy Center Mr. N.Enebish Director	National renewable energy center building, Bayangol district, XX horoo, Dund Gol-2. Tel: +976-11-686298 Email: renenergy@magicnet.mn	Implementation of project and programs in renewable energy sector. Technical monitoring, renewable energy sector research and development.
State Specialized Inspection Agency	Government building XII, Barilgachdiin talbai-13, 211238	Professional technical inspection, monitoring and control.

Mr. Ts.Shiirevdamba Director	Tel: +976-11-263790	

Academia

Name of the organization Contact person	Address Phone number Email contact	Description of products and services, role
Agricultural University of Mongolia Mr. B.Byambaa Rector	Tel: +976-11-341770, 341630, 341592 Fax: +976-11-341770 E-mail: infotech@magicnet.mn Web: www.msua.edu.mn	Research and specialist preparation in field of renewable energy and agricultural electrification.
Construction College Mr. B.Chimiddorj N.Nyamjav	Ulaanbaatar 44, P.O.Box: 276, Bayangol district, Peace avenue 35, Ulaanbaatar, Mongolia Tel: +976-11-322797, 70122723 Fax: +976-11-322797 E-mail: cwc@magicnet.mn	Professional training in construction and electrical engineering.
State University for Science Technology of Mongolia Power Engineering School Mr. B.Damdinsuren Rector	Main building of SUST, Sukhbaatar duureg, Ulaanbaatar, Mongolia Tel: +976-11-324709 E-mail: ddamdinsurenb@must.edu.mn Web: www.must.edu.mn	MUST is made up of seventeen professional schools, colleges and 3 research institutes and 36 experimental and technology centers whose faculty offer educational opportunities to students ranging from first-year undergraduates through doctoral-level candidates in engineering, technology, and others. 120 professors and over thousand staff are engaged in student training, educational and research activities, university administration and management. Power Engineering School is major institution for research and training of specialists in energy field.
State University of Mongolia Mr. Ts.Gantsog Rector	University street 1, Baga toiruu 1, Sukhbaatar district. Tel: +976-11-327911, 320160, 324385, Fax: +976-11-320668, 320159 Web: www.num.edu.mn E-mail: num@num.edu.mn	Research center of renewable energy. Training of specialists in the field of renewable energy.
Technical College in Darkhan-Uul aimag Mr. R.Lkhagvasuren	Tel: +976-1-372-23760, +976-99379687 Fax: +976-11-327234	Professional training in electrical engineering.
Ulaanbaatar University of Mongolia Dr. S.Baigalsaihan Rector	Tel: +976-11-458327, 456360, 453554, 458336 Fax: +976-11-458327 E-mail: UBV@magicnet.mn	Specialist preparation in field of renewable energy and M.Sc. study in renewable energy.

Companies (Electricity, Renewable Energy, Consulting, etc.)

Name of the organization Contact person	Address Phone number Email contact	Description of products and services, role
“ABE solar” Co., Ltd. Mr. B.Baatarkhuu	Tel: +976-11-327297, 91912224	Trade of SHS for small users and households. In 2006-2007 the company installed two wind energy systems

Director		(80kW installed capacity) for a soum center by order of the Government of Mongolia.
"Bayan Construction" Co., Ltd. Mr. D.Byuantogtokh Director	New Mega Power Center, 3-r horoo, Chingeltei district, Ulaanbaatar, Mongolia Tel: +976-11-319927, 319927, 91914968 Fax: +976-11-318257	Construction and trade company. In 2006-2007, the company installed PV and wind hybrid systems for four soum centers (150kWp installed capacity) by order of Government of Mongolia. Also in 2007-2008 delivered 40,600 units of 50Wp SHS for herders by order of Government of Mongolia.
"Bodi Group" Co., Ltd. Mr. Munkhnyam Manager	Bodi Tower, Sukhbaatar square Ulaanbaatar 210620A, Mongolia Tel: +976-11-313261, 313007, 313285 Fax: +976-11-326535 www.bodi.mn	Trade and engineering group of companies. Have facility for small scale PV module assembling.
"Khurd" Co., Ltd. Mr. B.Enkhjargal	Tel: +976-11-320697, 99118215, 88118215, 91912597 Fax: +976-11-325130	Civil construction company specializing in electrical and heating installations. In 2007 the company got contract to build PV system (150kWp installed capacity) for soum center by order of Government of Mongolia.
"MCS Engineering" Co., Ltd.	MCS Plaza, Seoul Street - 4, Ulaanbaatar-13, P.O.Box 1272, MONGOLIA Tel: 976-11-346363,346464 Fax: 976-11-326030 E-mail: mcsinter@mcs.mn www.international.mcs.mn	Engineering and consulting company specializing in energy sector including renewable energy (hydro, geothermal, PV technology).
"Mon-Energy" Co., Ltd. Mr. L.Erdenedalai Director	Energy research and Development Center, Chingis avenue, Khan-Uul district, Ulaanbaatar, Mongolia Tel: +976-11-632319 Email: mon-epdc@mongol.net	Consulting company specializing in energy sector.
"Mongol Alt" Co., Ltd. Mr. J.Munkhtur	Tel: +976-1-372-33263, 99114122, 99376169, 99081267	Mining company specializing in gold mining. In 2007 the company got contract to build wind energy system (150kW installed capacity) for a soum center by order of Government of Mongolia.
"MonMar" Co., Ltd. Mr. Ch.Batbayar	Renewable Energy Center Building II, Chingis Khan avenue, Khan uul district. Tel: +976-11-342692 Email: monmar@magicnet.mn	Production of mini wind chargers (50Wp), trade of wind and solar PV systems.
"Narnii Zai Service" Co., Ltd. Mr. D. Agchbayar	Khuch sport horoo, Tsergiin khothon 2-r horoo, Bayanzurkh district. Tel: +976-11-451787 Email: agch@magicnet.mn	Trade of PV systems for households and small users.
"New power" Co., Ltd. Mr. Baymbatsogt Director	Tel: +976-11-634256, 99050662, 99094921 Fax: +976-11-635246	Construction company. In 2007 the company got contract to build PV system (150kWp installed capacity) for a soum center by order of Government of Mongolia.
"Newcom" Co., Ltd. Mr. P.Gankhuayg General manager	Naiman zovkhis building, Seoul street 6/3, 210628 Tel: +976-11-313183 Email: info@newcom.mn	Investment company holding shares for engineering, energy, communication, airway companies. In 2007 the company signed first PPA contract in the country to construct wind farm in Mongolia. The company plans to introduce grid connected wind farm (50MW) by 2010.

“Prestige engineering” Co., Ltd. Mr. J.Dalai Director	Address: #501 Sukhbaatar square 3, Ulaanbaatar, Mongolia Tel: +976-11-313392 Email: centre@magicnet.mn	Trade and engineering company specializing in water supply business. In 2007 the company installed 80kW wind system for a soum center of Mongolia by order of Government of Mongolia. In 2007 the company got Government order for feasibility study preparation of hydro power plant.
“Sobby” Co., Ltd. Mr. B.Batchuluun Director	Teeverchdiin-35, Bayangol district, Hermes center. Tel: +976-11-368030 Email: sobbi@mongolnet.mn	Trade of PV systems for households and small users. Official distributor of “Southwest wind power” (US) wind turbines.
“Uureg Trade” Co., Ltd. Mr. O.Bayar Director	Tel: +976-11-687883, 99112727, 99112368 Fax: +976-11-688130	Entertainment business, construction and trade company. In 2006-2007, the company installed PV and wind hybrid systems for a soum center (150kWp installed capacity) by order of Government of Mongolia.

Institutional infrastructure and incentives available for the promotion and utilization of renewable energy in the country

The Parliament of Mongolia

As for all other national policies, the Parliament of Mongolia (State Great Khural) is in charge of approving the state policy in energy sector and to make a final decisions regarding construction of a nuclear power plant. The Parliament also approves strategy documents for promoting a renewable energy sector.

In recent years, the Parliament of Mongolia adopted several important legislations and national programmes for the promotion of renewable energy resources utilization. In this regard, the Energy Law settles to transfer the energy system into market principles, creates independent regulatory mechanism, conditions the private sector participation to the energy system and creates legal environment for promoting competition in the sector. The Renewable Energy Law settles to regulate generation and supply of energy utilizing renewable energy sources. Energy Regulatory Authority of Mongolia is obliged to approve model of power purchase/sales agreement based on feed-in tariff for renewable energy generation. The National Renewable Energy Program targeted to support renewable energy development in Mongolia. The program targeted to increase the share of renewable energy in total energy production by supporting construction of renewable energy power sources in two stages. In first stage (2005-2010 near term) the country should reach 3-5 percent share of renewable energy in total energy production and 20-25 percent in second stage (2011-2020 midterm).

The Government Cabinet

The Government Cabinet organizes the implementation of the state policy and legislation on energy; establishes the Energy Regulatory Authority and approve its articles of association; approves rules on consumption of heat and electricity and protection of power lines and networks and determine the frame of transmission networks; organizes implementation of laws and legislation on renewable energy; and approves a list of soums to be supplied with electricity and heat generated by an independent renewable energy power source.

Ministry of Mineral Resources and Energy

The Ministry of Mineral Resources and Energy (MME) is the line ministry in charge of policy development on use of energy and energy resources. This includes the development of energy resources; energy use; import and export of energy; construction of power plants, lines and networks; energy

conservation; use of renewable energy sources; dissemination of renewable energy technologies. It is also responsible for monitoring the energy sector, approving rules and regulations for the sector and international cooperation projects; and disputes resolvement regarding licensing and revocation of licenses.

According to Law on Renewable Energy, MME has the following full powers in regard with renewable energy sector:

- to develop and implement strategy documents for renewable energy sector,
- to develop research, investment and feasibility studies for constructing renewable energy power sources to be financed by public investment funds,
- to develop and have approved the maintenance, safety, and operation standard of renewable energy equipment in compliance with relevant procedures, and
- to develop a policy on renewable energy human resources, to organize implementation of this policy in collaboration with the State Central Administrative Authority in charge of education
- to develop and have approved regulation on implementation of Renewable Energy Law

Local Governors

The Governors of Aimags, the Capital City, Soums and Districts organize the implementation of legislations and decisions issued by the authority in charge on energy supply in their respective territories. Local Governors determine starting and ending dates of the heating season based on regional climatic conditions; make a decision on providing land for constructing independent renewable energy power sources use in compliance with procedures stipulated in laws; advertise importance of using renewable energy to entities, institutions and residents, and to lease locally owned independent renewable energy power sources to an entity or an individual.

Energy Regulatory Authority

The institution for regulating the energy generation, transmission, distribution, dispatching and supply of energy, is the Energy Regulatory Authority of Mongolia (ERA). It was established in July 2001 as an independent regulatory organization to implement the Law of Mongolia on Energy. The Regulatory Authority is governed by the Regulatory Board consisting of three Regulators. The Chairman and Regulators of the Board are appointed by the Prime Minister based on a proposal of Minister of Energy. The Regulators have a status of state energy inspectors. The Regulatory Authority shall be funded by licensing fees and charges for regulatory services provided to licensees.

ERA's main duties include the issuing of licenses to energy companies and other organizations operating in the sector. ERA also reviews and approves energy tariffs throughout Mongolia. It monitors the implementation and compliance with the terms and requirements of the licenses and approved prices and tariffs and is also complaint and dispute resolvement body. Duties of the Regulatory Authority shall be to regulate generation, transmission, distribution, dispatching and supply of energy.

Energy Authority

Besides of ERA, there is currently an implementing agency under the MME, the Energy Authority. The EA is responsible for the organization of research for utilization of energy resources; project and program implementation; conducting feasibility studies; research for new technologies and technology transfer; renewable energy resources assessment; research for energy efficiency; and developing standards, norms and safety regulations; and technical monitoring of construction of energy facilities in the country. Energy Authority is also responsible for developing international cooperation in the energy sector. Scheme of strategic management of the Energy Authority is shown in Figure 12.

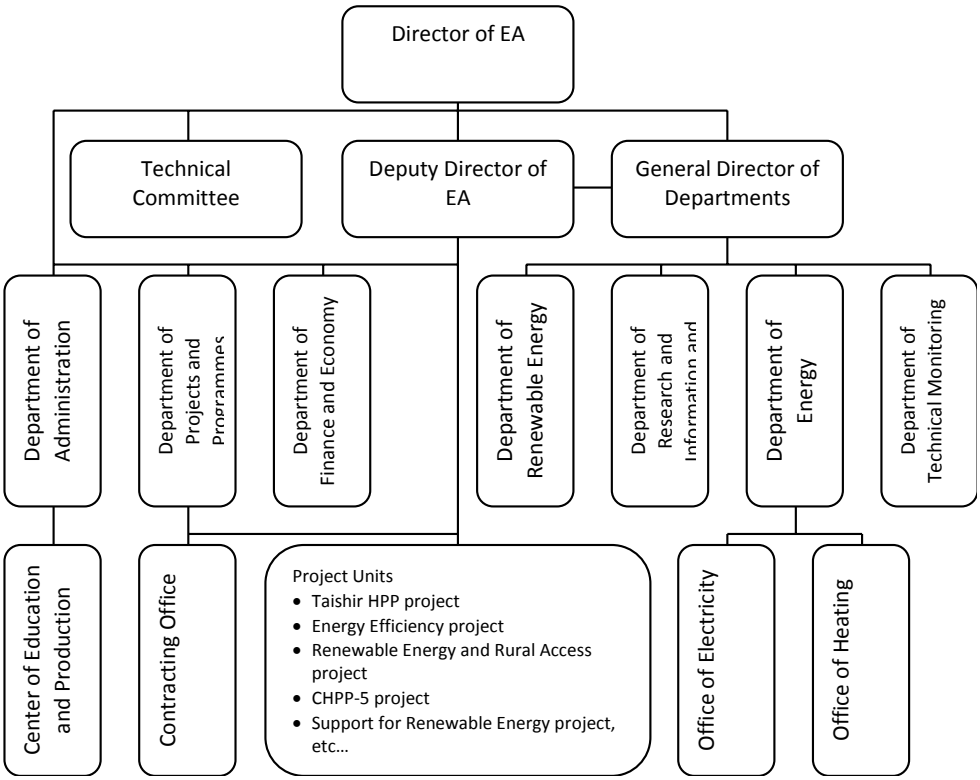

Figure 11: Institutional structure of the Energy Authority

Figure 12: Scheme of Strategic Management and Coordination of the Energy Authority

Ministry of Finance

Since energy sector enterprises are state-owned, major investments such as building transmission and distribution lines and networks have been implemented by the Ministry of Finance (MoF). It is also responsible for budget planning and budget supervision of ministries, agencies and local authorities.

Ministry of Nature and Environment

Finally when it comes to the application and registration of CDM projects, the Ministry of Nature and Environment (MNE), is acting as the national designated authority for clean energy development mechanism. It has formed the National Bureau of Clean Development Mechanism. The energy sector of Mongolia is the largest contributor to Greenhouse Gas (GHG) emissions. The cold continental climate, the reliance on wood and the low energy value of Mongolian coal contribute to a high rate of carbon dioxide (CO_2) release when measured on a per-capita basis. Estimated national CO_2 emission for 1990 was 19.1 million tons or roughly 7.9 tons per-capita. This is greater than the per-capita rates for Southeast Asia (excluding Bangladesh and Malaysia), Africa, and exceeds the world average. Using current

estimates of population growth, Mongolia may experience a three-fold increase in energy demand by the year 2020.[9]

For Mongolia the risk of climate change or even prolonged extreme climatic events could have dramatic impacts on its economy and natural systems, with the potential in some cases for irreversible damage to ecosystems. Agriculture, including crop and livestock production, water and forest resources, as well as biodiversity, is among the most vulnerable systems.[10]

Currently, there are four projects have been registered for CDM.

Policies, policy instruments, and related measures available in the country for the promotion, utilization and development of renewable energy technologies (RETs)

Due to the absence of a centralized supply system, low demand and lack of other energy sources, renewable energies are considered to be the optimal, and in most cases, the only option for rural electricity supply in Mongolia. Mongolia has ratified the United Nations Framework Convention on Climate Change in 1993 and Kyoto Protocol in 1999, and is committed to its main objective of stabilizing emissions of greenhouse gases at levels that prevent dangerous interference with the climate system.

Table 5: Renewable Energy Policy Landscape:

Renewable Energy Targets	"National program for renewable energy" had been adopted in 2005. The program targeted to reach 3-5 percent share of renewable energy in total energy production by 2010 and reach 20-25 percent of share by 2020.
Renewable Energy Promotion Policies	In 2007, the "Renewable Energy Law" had been adopted.
- feed-in tariff	Yes, depending on type of renewable energy source followings tariffs had been set: Grid connected wind power: 0.08-0.095USD/kWh; Grid connected hydro power (up to 5MW installed capacity): 0.045-0.06USD/kWh; Grid connected solar power: 0.15-0.18USD/kWh; Stand alone wind power: 0.10-0.15USD/kWh; Stand alone hydro power: 0.08-0.10USD/kWh (up to 500 kW), 0.05-0.06USD/kWh (from 501 to 2000 kW), 0.045-0.05USD/kWh (from 2001 till 5000 kW); Stand alone solar power: 0.2-0.3USD/kWh.
- renewable portfolio standard	No
- capital subsidies, grants, rebates	No
- investment excise, or other tax credits	No
- sales tax, energy tax, or VAT reduction	No
- tradable renewable energy certificates	No
- energy production payments or tax credits	No
- net metering	No
- public investment, loans, or financing	The Government of Mongolia invested in 12 renewable energy systems for soum centers in 2007-2008 according to procurement law of Mongolia (direct contracting method had been used).
- public competitive bidding	The Government introduced renewable energy in 4 soum centers in 2006-2007 using public competitive bidding.
Municipal-Level Policies	No

[9] Energiesektor der Mongolei, Ist-Situation und Perspektiven im Hinblick auf TZ Ansätze, 2004

[10] MNE, NAPCC, Climate change and sustainable livelihood of rural people in Mongolia, 2006

Rural Energy Policies	Yes. It targeted to electrify all soum centers (administrative unit in the country) using grid extension or renewable energy technology (about 16 soum targeted to be electrified by renewable energy according to "Integrated energy systems of Mongolia" adopted in 2000 and updated in 2007). In 2001 the Government of Mongolia initiated "100 000 solar ger" national program to electrify rural herders by PV systems. Up to May 2008, other 70,000 SHS had been delivered to herders by subsidized price.	
CDM	Framework Convention on Climate Change ratified in	1993
	Kyoto Protocol ratified in	1999

Source: UNDP, 2008; State budget law of Mongolia 2006, State budget law of Mongolia 2007, State development fund law of Mongolia 2007, Renewable energy law of Mongolia, National program for renewable energy of Mongolia.

Energy Law

In 2001, the Parliament approved the Energy Law, and the Government has started its enforcement. In this regard, important steps have been taken to transfer the system to market principles, create independent state regulatory mechanism, create conditions for private sector to enter the energy system and create the legal environment for promoting competition in the sector. A crucial part of the energy sector restructuring has been the creation of an independent regulatory mechanism – establishment of the Energy Regulatory Authority, which enables investment and operation by new domestic and foreign economic entities. State owned energy entities have been dismantled according to their lines of business and in their place 18 shareholding companies and companies with limited liabilities have been established. The shares of these companies are owned by the Ministry of Mineral Resources and Energy, State Property Committee, Ministry of Finance, according to provisions of the relevant legislations.

Mongolia Sustainable Energy Sector Development Strategy Plan

The plan has been approved by Government Resolution #140 on July, 2002. The plan includes: Strengthening of the financial independence of the sector, to ensure that the energy sector provides an impetus for the country's economic and social development, to mitigate and gradually eradicate the sector's burden for the state budget; Implementation of structural reforms, to commercialize the sector and increase the participation of the private sector; Improving the structure, organization and managerial capacities, to ensure successful transition of the sector to the market relations; Improving the supply of energy and creating a pricing mechanism tied to the subsistence level, to ensure that the users in rural areas and low-income clients benefit from the restructuring of the sector; Consideration of energy efficiency measures; Increasing the efficiency of the energy sector and accelerate economic growth the utilization of cheap energy resources as hydro power and other REs will be expanded; Introduction of a flexible energy price and tariff system in order to provide the minimum energy and heat needs of poor citizens; In order to ensure accessibility of public services to the rural population, in particular, to the remote soums and settlements; to develop small and medium size enterprises, and to meet the household needs of citizens, the renewable energy resources will be broadly used.

Integrated Energy System Program

The program was approved in May 2002 by the resolution #23 of the State Great Hural and amended in Jan 2007 by the resolution #10 of the State Great Hural. The program is dealing with the near- to long-term strategy on power sector. The program will be implemented in the following stages: First stage - Near term (2007-2012): Supply all the soum and rural centers with sound electricity by enhancing the reliability of existing regional electricity supply, by constructing new generating sources, transmission lines and from the renewable energy sources; Second stage - Midterm (2012-2022): Set up preconditions for interconnecting CES, EES and WES and the establishment of Integrated Energy System by further constructing new generating sources and transmission lines; Third stage - Long term (2022-2040): Establish Integrated Energy System by interconnecting CES and WES via high-voltage electricity

transmission line. The program will be financed from state or regional budgets, domestic or international investments, international soft loan and grant aids, private investment, and other possible sources.

National Renewable Energy Program

The Parliament of Mongolia adopted National Renewable Energy Program on June, 2005, document targeted to support renewable energy development in Mongolia. The program targeted to increase the share of renewable energy in total energy production by supporting construction of renewable energy power sources in two stages. In first stage (2005-2010 near term) the country should reach 3-5 percent share of renewable energy in total energy production and 20-25 percent in second stage (2011-2020 midterm). In the first stage of the program, Durgun (12MW) and Taishir (11MW) hydro power plants were constructed, "100000 solar ger" national program was launched and 12 renewable energy systems for soum centers with capacity of 60-150kW were constructed. Furthermore, launching construction of Orkhon (100MW) hydro power plant, making feasibility studies of hydro power plants for future construction, conducting studies of grid connected wind farms and conduction of research in new technologies such as fuel cell, hydrogen power sources, were planned. In the long term, the program targeted to introduce grid connected wind farms and large scale PV power generating system in Gobi desert area. According to the decree of Parliament of Mongolia on approval of National renewable energy program the Government of Mongolia is charged to raise funds to implement the program from following sources: state budget of Mongolia, from involvement of domestic investors, international donors and use of CDM.

"100000 Solar Ger" National Program

The Government of Mongolia initiated "100000 solar ger" national program to electrify herders in rural area of Mongolia in 2001. Initially program targeted to introduce SHS to 100,000 herder families by Government support. Latter in 2005 during preparation of the National Renewable Energy Program the "100000 solar ger" program has been updated to reach all herder families in the country. By May of 2008, other 70,000 herder families received SHS by 50 percent subsidized price out of 170,000 herder families in the country. The program targeted to utilize state budget, state development fund and international donor's financing. In first stage of the program grant from Government of Japan and grant from Government of PRC had been used and in the second stage 40000 sets of 50Wp SHS had been procured and delivered to the herders by half of initial price by funding of state budget and state development fund.

Renewable Energy Law

Renewable Energy Law had been adopted by Parliament of Mongolia in January, 2007. The law is settled to regulate generation and supply of energy utilizing renewable energy sources. According to the Renewable energy law of Mongolia the Energy Regulatory Authority of Mongolia is obliged to approve model of power purchase/sales agreement based on feed-in tariff for renewable energy depending from utilized type of renewable energy. The feed-in tariff for renewable energy is shown in Table 6. The price and tariffs of renewable energy is set to be stable for a period of minimum ten years starting the date of entry into force of the law. To support the set price of renewable energy in rural area, the law obliged to the Government to form renewable energy fund. The law stated to be not applicable to a state-funded renewable energy power source.

Table 6: Feed-in tariffs for the electricity from renewable energy plants

Source	Type	Capacity range	Tariff (USD/kWh)
Solar power	Grid connected		0.15-0.18
	Stand alone		0.2-0.3
Wind power	Grid connected		0.08-0.095
	Stand alone		0.10-0.15
Hydro power	Grid connected	up to 5MW	0.045-0.06
	Stand alone	up to 500 kW	0.08-0.10

		501-2000 kW	0.05-0.06
		2001-5000 kW	0.045-0.05

The power sector including the renewable energy generation and rural electrification is primarily governed by the Energy Law and the Renewable Energy Law. The purpose of the Energy Law is to regulate matters relating to energy generation, transmission, distribution, dispatching and supply activities, construction of energy facilities and energy consumption that involve utilization of energy resources. The purpose of the Renewable Energy Law is to regulate relations concerning generation and supply of energy utilizing renewable energy sources. Other relevant legislations include Environment Protection Law, Law on Environmental Impact Assessment, Law on Land, Law on Construction and Law on Water.

Construction and operation of power plants, including renewable energy systems, with capacity 1.5MW and lower and construction of its transmission and distribution lines that do not have any adverse impact on the environment and normal living conditions of people and are designed for own use, are not subject to license. Energy Regulatory Authority issues a license for electricity generation, heat generation, electricity transmission, heat transmission, dispatching, electricity distribution, heat distribution, regulated supply of energy, unregulated supply of energy, importation and exportation of electricity and construction of energy facilities. A license for construction of energy facilities shall be granted upon assessment of the environmental impact in accordance with Law on Environmental Impact Assessment.

Details of financial institutions supporting RE projects (including brief illustrative examples and status of the projects funded)

Currently, there are several renewable energy projects are underway. World Bank financed **"Renewable energy and rural electricity access project"** became effective on May 4th, 2007. The project aims to increase access to energy of rural population of the country. The project consists of 3 components such as: herder electricity access, soum electricity access, and national capacity building. The project is financed by International Development Agency, Global Environmental Fund, Government of Netherlands and Government of Mongolia. Total cost of project is 13 million USD, which is 100% grant, excluding financing of Government of Mongolia.

KfW bank financed **"Renewable energy II"** project is working on rehabilitation of Bogdyn HPP (2MW) in Zavkhan aimag and the distribution network in Uliastai. The rehabilitation of Bogdyn HPP is completed in 2007. The consulting company is joint venture Lameier International and Decon GmbH (Germany). Another line of study of the project is a grid-connected wind park in Gobi region of Mongolia.

The European Bank for Reconstruction and Development will provide technical assistance to the Energy Regulatory Authority of Mongolia with respect to the implementation of **"Renewable Energy Regulatory Development Road Map"** project. The project will cover assessment and improvement of feed-in tariff regime related to electricity produced utilizing renewable energy sources; assess least-cost options for developing renewable energy in Mongolia; assess affordability of renewable energy in the country; and formulate a renewable energy regulatory development road map up to 2020. Project funding is 290,000 euros from Japan-Europe Cooperation Fund.

GTZ financed **"Promotion of renewable energy in Mongolia"** project is implemented by the MME and EA as Mongolian counterpart, and Integration Umwelt & Energie GmbH as German counterpart. The third stage of the project, started in 2008, focuses on the following aspects: Supporting the establishment of renewable energy regulatory framework, implementing projects on grid-connected renewable energy systems, capacity building, supporting the introduction of solar thermal applications and dissemination of

technologies, and supporting the set up of renewable energy professional training curriculum and training materials.

During 2007-2008, **Government of Mongolia** has financed 12 solar-wind hybrid systems in soum centers. Total cost of the project is 8.9 billion MNT and total installed capacity of the hybrid systems is 1.36 MW. In 2007-2008, as part of "100000 solar ger" national program 40,400 sets of 50Wp SHS had been procured and delivered to the herders by half of initial price by funding of state budget and state development fund of Mongolia.

Various renewable energy and energy efficiency project were implemented to date, financed both by the Government of Mongolia and international donors. These projects are briefly summarized in the following Tables.

Table 7: Projects financed by the Government of Mongolia

Name of projects	Ordered and implemented by	Results
Sophisticated utilization of the solar and wind energy in the state economy, construction of trial equipments and plants (1989-1990)	MFE, REC	▪ The solar collector, biogas digester, movable type of wind generator were invented and tested.
Wind energy (1991-1993)	MoI, REC	▪ Wind energy measurement in Manlai soum, Umnugovi province
Solar and wind energy (1994-1996)	MFE, REC	▪ The alternate forms to provide the herdsmen families with electricity, using renewable energy was processed and tested in the real condition.
Assessment of solar and wind energy resource in Mongolia and technology of its utilization (1997-1999)	MFE REC	▪ Assessment of solar and wind energy resource in Mongolia was determined and map of resource was made. ▪ The further development plan of renewable energy utilization in Mongolia was processed. ▪ Drawing of solar house was processed.
Small scale electricity generating solar-wind hybrid system (1999-2000)	MFE REC	▪ Selection of small wind generator that can be used in Mongolian condition was made. ▪ On site experiment of supplying rural small users with solar and wind energy
Study on possibilities to build wind farm with capacity of 25-30MW (2002-2003)	MoI REC	▪ Feasibility study on wind farm with capacity of 46MW ▪ Wind measurement in target area

Table 8. Renewable energy projects implemented and supported by international donors

Name of projects	**Implemented and supported by**	**Results**
Applied research and development for rural use of renewable energy MON 86/005 (1986-1990)	UNDP REC	▪ Wind generator factory ▪ Renewable energy laboratory
Research of portable type photovoltaic power generation system for demonstration (1992-1997)	NEDO REC	▪ On-site experiment and test of 3 types of 200 PV systems for herdsmen families in all areas of Mongolia
Study on utilization of solar and wind energy in Mongolian rural areas (1993)	DANIDO	▪ Study and advice on electrification of Bag center and local centers using renewable energies

Photovoltaic manufacturing plant (1998)	ADB, NF PTA	▪ Photovoltaic manufacturing plant with annual production of 0,5MWt photovoltaic panel
Rural electrification from renewable energy sources in Mongolia (1998-2000)	TACIS REC	▪ Assessment of solar and wind energy resources in 5 soum centers in Gobi region ▪ On site experiment and test of electricity supply of hospital, school and dormitory in 3 soum centers using solar and wind energy
Master plan study for rural power supply by renewable energies in Mongolia (1998-2000)	JICA REC	▪ Master plan study of renewable energy development in the period of 2005, 2010, 2015 ▪ 5kW solar and wind pilot plant in 3 soum centers
Wind energy resource assessment of Mongolia (1998-2000)	USAID, NREL REC	▪ Wind measurement in Gobi region ▪ Atlas of wind energy resource in Mongolia
Utilization of renewable energy in rural area of Mongolia (1999-2007)	GTZ REC	▪ On site experiment on utilization of renewable energies in Zavkhan province
Demonstration research project on dispersed photovoltaic power generation systems in Mongolia (2002-2004)	NEDO MoI	▪ Photovoltaic power plant with capacity of 200kW was built in Noyon soum, Umnugovi province
Rehabilitation of HPP on Bogd River, Zavkhan province (2003-2004)	KfW	▪ Repair work of headrace channel of HPP on Bogd River
Nomadic electrification (2003)	JICA	▪ Distribution of 11500 photovoltaic systems with capacity of 62W
Erdenebulgan (2003)	DANIDO	▪ Construction of HPP with capacity of 200kW
Development of renewable energy utilization in local centers and rural areas (2003)	ADB	▪ Research project
Project of HPP on Eg River (1998)	ADB	▪ On-site study of HPP and techno-economical feasibility study ▪ Drafts and blueprints
Taishir HPP (2000)	KF FEA	▪ Drafts and blueprints of HPP on Zavkhan River with capacity of 12MW was made ▪ Tender for construction
Study on HPP on Orkhon River (2002)	JICA FEA	▪ Techno-economical feasibility study on HPP on Orkhon River with capacity of 100MW
Solar power systems for soum center hospitals and schools (1998-2000)	Bavaria	▪ Installation of solar power system for school and hospitals and 100 herdsmen families in Zavkhan and Khuvsgul provinces
Taishir HPP (2001-2008)	Kuwait Fund Abu-Dhabi Fund GoM	▪ Construction of Taishir HPP

Table 9. Energy and heat efficiency projects implemented and supported by international donors

Name of projects	**Implemented and supported by**	**Results**
Energy conservation and monitoring, 1750 TA MON	ADB	▪ Study and evaluation on energy systems ▪ Study on possibilities of energy saving and improving efficiency
Energy conservation project, MON 1492	ADB FEA	▪ Installation of flow meters in main pump stations in Ulaanbaatar and installation of thermal energy meters in main consumers ▪ Construction of 6km pipeline, installation of 39 valves and renewal of 2 pumps in TEPP-2 ▪ Pilot project on energy saving in residential buildings

		▪ Installation of meters and transformers on main electricity transmission lines
Improvements to energy supply in Darkhan and Choibalsan, Mongolia	TACIS Erchim khemnelt Co., LTD.	▪ Study on larger consumers in Darkhan, seminars ▪ Feasibility study on rehabilitation of heating systems in Darkhan ▪ Feasibility study and program on rehabilitation of heating systems in Choibalsan
Ulaanbaatar heat rehabilitation project	ADB	▪ Renovation of heating system in Ulaanbaatar as automatic regulated system ▪ Replacement of pumps on distribution network of TEPP with automatic regulated pumps ▪ Rehabilitation of heating center ▪ Installation of heat energy meters on consumers ▪ Improvement of capacities of sub distribution network ▪ Installation of meter on hot tap water supply system ▪ Pilot project on heating centers
Energy efficiency strategy for the district heating systems in Ulaanbaatar	WB	▪ Study on loss in heating system ▪ Processing of concepts for improving efficiency
Study on rehabilitation of electricity distribution network in Ulaanbaatar	WB	▪ Processing of loss evaluation technique for bigger consumers and distribution systems, training for operating equipments of collecting system data
Study on rehabilitation of electricity distribution system in Ulaanbaatar, Dornod and 6 provincial centers	WB	▪ Renewal of distribution transformers, transmission lines and installation of meters in suburbs of Ulaanbaatar, renovation of income collecting system ▪ Renovation of 1 substation in Dornod, study on system loss reduction in 7 provincial centers
Implementation of energy conservation programs and rational use of energy in Mongolian industry	TACIS	▪ Pilot project in industries such as APU, Mongol Nekhmel, Pharmaceutical factory, Eermel and Makh Impex

Scope for utilizing renewable energy in the country

Depending on the region solar, wind and hydro power can be used for power generation. In most areas, renewable energies are even optimal because of the low demand and lack of other energy sources.

Renewable energy so far plays an important role in two distinct areas:

- Stand-alone home renewable energy systems to provide electricity for nomadic households and
- Off-grid village renewable energy systems to provide electricity for rural centers.

Stand-alone home renewable energy systems: One of the main demands for developing renewable energy utilization in Mongolia is to provide electricity supply to rural nomadic households. Due to nature of nomadic lifestyle, rural families live far from each other and from the rural centers, constantly moving from a place to another looking for better grazing for their livestocks. They need some source of energy supply to cover their basic needs such as lighting their homes, listening to radio and watching TV.

Stand-alone electricity supply for nomadic households is mostly provided with small solar home systems and small wind generators. A national programme “100,000 Solar Ger” aimed at providing portable solar

home systems to nomadic families was successfully implemented. As a result if the programme, about 103,000 nomadic households light their homes from solar PV modules (20-200W) and/or small wind generators (50-300W).

Off-grid village renewable energy systems: Mongolia is one of the most scarcely populated countries in the world. The main economic sector is still being livestock farming besides mining and industry. Monholia is divided into 21 aimags (provinces) and 334 soums (counties). Soum center is a small settlement that provides social and administrative services for the nomadic households living within the soum territory. It includes hospitals, schools, administration units, services and small businesses etc. Centrailzed electricity supply for soum center is not economically viable due to remoteness of the soum center and low end-user demand.

In this regard, a number of stand-alone solar-wind-diesel hybrid systems (or various combinations of them) with capacity of 20-180kW, supplies electricity to rural centers. 200kW PV system in Noyon soum, Umnugovi aimag which is the biggest, is in operation. 100kW wind turbine, which is currently the biggest, was installed in Erdenetsgaan soum, Sukhbaatar aimag. A number of PV systems (20-100kW), wind power systems (70-150kW) and PV-Wind hybrid systems (100-150kW) are in operation, over the country. The “National Renewable Energy Program” targeted to supply number of soum centers from the off-grid renewable energy systems, in the mid-term.

On-grid renewable energy systems: Role of renewable energy in grid connected electricity supply is currently negligible but through the new feed-in mechanism set by the Renewable Energy Law, role of on-grid renewable energy is expected to increase. A first 50MW on-grid Wind Park near Ulaanbaatar is underway and power purchase agreement was signed between the developer and the single-buyer.

Mongolia is rich in wind and solar energy resources. The “National Renewable Energy Program” targeted to introduce grid connected wind farms and large scale PV power generating system in Gobi desert area, in the long-term. Several sites for wind farm application are being studied and wind measurements are underway.

A number of hydro power sites (namely Orkhon HPP 100MW, Egiin Gol HPP 220MW) have been studied for feasibility during the last few years for on-grid supply. Taishir (11MW) and Durgun (12MW) HPPs were built during 2007-2008 and it supplies electricity to the regional grid. Large HPP installations create a center of attention because of its maneuverability and better dispatching capability for the centralized grid system, which is currently purchasing auxiliary services from the Russian grid.

Indigenously developed RETs

The most successful application of renewable energy technologies in Mongolia is being application of small-scale solar home systems for nomadic households. One of the main reasons for developing renewable energy utilization in Mongolia is to provide electricity supply to rural nomadic households. For this purpose, “100,000 Solar Ger” national program was launched in 1999. Within the framework of the national program, small-scale solar home systems suitable for lighting and watching TV were provided to nomadic households. Both state budget and international grant aids were used for financing. Today, 103,000 nomadic households have solar home systems with capcity of 20-100W.

Table 10. Results from “100,000 Solar Ger” national program

Type of solar home systems	Quantity	Remarks

62W solar home systems by Japanes grant aid	11,170	System set was manufactured in Japan and China. Mast was manufactured in Mongolia.
20W, 50W, 75W solar home systems by Chinese grant aid	20,620	Manufactured in China.
50W solar home systems by Mongolian state budget	40,400	Purchased from China.
Total	**72,190**	
From other sources	About 30,000	Including imported and local-made solar home systems.
Grand total	**About 100,000**	

Nomadic households received their solar home systems with 50% subsidized price. Loan from local banks were available for buying the system.

Figure 13: Nomadic household with a solar home system and satellite TV.

Nomadic households have learned to use, manage and care the solar home systems without any problem. Nomadic families constantly move from a place to another looking for better pasture for their livestocks (at least 4 times, up to 10-15 times a year). PV system is being the most suitable option for the nomadic lifestyle because of its portability, easy installation and simple use.

As a result of previous studies, following options were proposed for supplying nomadic households with electricity. Usually, several nomadic families live together in the same place. It gives a possibility for them to choose from the the below options depending on their their budget and power demand. A family with smaller system could possibly upgrade their system later.

Lighting (PV) ≤ 100 Wh per day ⇒

Lighting & TV (PV, PV+Wind) ≤ 200 Wh per day ⇒

Satellite TV (PV, PV+Wind) ≤ 300 Wh per day ⇒

Nomadic electricity (PV, PV+Wind) ≥ 300 Wh per day

Figure 14: Options for supplying nomadic households with electricity

"100,000 Solar Ger" national program has supplied solar home systems that are comparable to "Lighting" or "Lighting & TV" option. Grant aids from international donor organizations played important role in successful implementation of the national program.

Selection of system size for the options of nomadic electricification is shown below.

Table 11. Size of the solar home systems for nomadic households

Options	Size of PV	Size of battery
Lighting (Light and Radio)	Minimum - 24W	Minimum - 50Ah
Lighting & TV (Light, Radio and TV)	Minimum - 50W	Minimum - 100Ah
Satellite TV (Light, Radio, TV, Satellite receiver and small refridgerator)	Minimum - 150W	Minimum - 170Ah
Nomadic electricity (possibly with ~220V inverter)	Minimum - 200W	Minimum - 250Ah

Nomadic households need to use refrigerators during the summer where solar radiation is highest. "Satellite TV" option would give them such a possibility. "Nomadic electricity" option would give nomadic households a chance to use a shallow-well pump for watering their livestocks and irrigating pasture land.

Since 1970s, first attempts were made to supply Mongolian nomadic families with electricity. Depending on the technological developments of the time, various options were tried.

Table 12. Attempts to supply nomadic households with electricity.

Year	Source of energy	Type	No. of households	Remarks
1970-1990	Gasoline	Portable internal combustion engine generator	13,000	Imported
1980-1990	Coal	From thermal power plant	In few households	For the nomadic households near the transmission line
Since 1990s	Wind energy	Wind turbine (Ruthland type - 50W)	Around 2,000	Manufactured in Mongolia. Technology transferred from Ruthland Co. LTD of England.
		Wind turbine (FD type - 100W)	Around 1,000	Imported from China
1990	Solar energy	PV - Lighting system (Amorphous silicone - 11W)	3,000	Imported from China
1992	Solar energy	Fully portable PV system (Kyocera Corporation - 200W)	200	Pilot project by NEDO of Japan. Portable PV systems with measurement facilities were tested in real-life situation.
Since 1997	Solar energy	PV assembling factory was built in Mongolia (using imported solar cells)	1,500	Manufactured in Mongolia

Around 2000	Solar energy	PV system with radio station (JICA of Japan - 100W PV)	Around 1,000	Used for communication between rural administration units. Most of them are removed now due to increased access to mobile phone.
2003	Solar energy	PV system (Sharp Corporation - 50W)	11,170	Japanese grant aid
2004	Solar energy	PV system (Suntech Corporation - 20W, 50W and 75W)	20,620	Chinese grant aid
2007	Solar energy	PV system (Imported from China - 50W)	40,400	Mongolian state budget

Developing effective system for delivering weather forecasts to rural administration units and disaster response was important in order to prevent natural disasters. For this purpose, JICA implemented Rural Communication Project with great success. The project supplied around 1000 radio-communication stations with PV system to rural administration units.

PV system with capacity of up to 100W was most suitable for nomadic household due to its size and weight. Bigger systems were less favored because of portability.

Barriers faced in transferring RETs

Main barriers in transferring renewable energy technologies Mongolia is being faced in electricity supply of rural centers from renewable energies. 11 HPPs, 6 wind-solar hybrid systems, 3 solar PV systems and 5 wind power systems were built to date for supplying rural centers with electricity. If combined with diesel generators, these systems should be capable of supplying rural centers with electricity all year around.

Of the above systems, twelve wind and solar (or hybrid) systems were built during 2007-2008 using state budget. But these systems are facing frequent failures or shortage of capacity without diesel back-up. Depending on the future operation and the system improvement, the renewable energy systems can be expected to spread as a typical stable system model. However, there are still a lot of problems to be solved. In order to identify the problems, both World Bank and GTZ provided their evaluations on the situation of the systems. There are several common problems that must be solved in order to spread the renewable energy system for rural electricity supply:

- System configuration.
    - Hybrid systems are not functioning as an ideal system configuration. The goal of hybrid system is a total cost reduction with optimal cooperative operation of diesel generators and renewable energy systems. But, the hybrid systems are not being backed-up with the existing diesel generators. Method of the system design and operation method needs to be reviewed to make the systems ideal in the future.
- Quality of the component
    - Quality and performance of system components are generally poor, and some systems are found to have malfunctions and frequent failures. Equipments and installation services are not met with the basic international standards. Performance evaluation of the installed components and continual effort to select component with high reliability and high performance are required. Additionally, improvement on the method of performance evaluation and the acceptance tests is required.
- Operation and management
    - Lifetime of the batteries considerably depends on the operation and management. The fact is that operation and management of the batteries in each soum depend only on the voltage monitoring. So, accurate management of the depth of discharge is required.

Additionally, from the safety point of view, installation of ventilation facilities and safety training for operators are indispensible.
    - All the customers are been paying flat tariff and no metering systems and circuit breakers are installed at the end customers.
- Electric power quality
    - Large voltage drops and low voltage of distribution lines at terminal are found in some soums. The voltage drops are making troubles on television screen, fluorescent light, electric heater, etc.
    - Improvement on the configuration of distribution lines and modification of set point of voltage at power station are required. Furthermore, improvement for the reduction of harmonics and three-phase imbalance is required, because these phenomena have bad effect on the facilities of power station and electrical appliances of customers.

It is being very important to solve the problems and build up a store of knowledge and experience that will be necessary when building new system in the future. Therefore, data accumulation and data analysis are very important. The data will be valuable to build optimal system in Mongolia. In addition, conducting detailed analysis of the system, such as performance of components, failure frequency and parts supply and maintenance system of the manufacturers will make it possible to find suitable components which fit for regional characteristics of Mongolia.

Main sources of problems facing renewable energy development in Mongolia are:

- Lack of finance and lack of management
- Lack of knowledge for developing system configurations and selecting system components
- Shortage of domestic private companies specialized in renewable energy
- Lack of effort for using energy efficiently
- Disregarding international standards
- Lack of technical monitoring during installation and lack of performance test evaluation and
- Lack of training of operators and capacity building

Developing original system configuration of Mongolia will be important in order to promote the installation of renewable energy systems in the future. There is a need to take the initiative of that approach and nurture domestic private companies. The renewable energy system development should be raised as a new domestic industry in order to promote the renewable energy in Mongolia.

Strategies and future development of renewable energy

Mongolia has abundant coal resources, but burning coal for energy production and low energy content of Mongolian lignite coal makes a lot of environmental problems. All the major thermal power plants are located within the cities and it makes the problem even worse. Besides smoke, dust and ash, significant amount of radioactive waste is released after burning the coal from Baganuur coal-mine, which used for all the major thermal power plants.

Significant fraction of Mongolia's population lives in shortage of electricity, heat and fuel supply. Fuel and heat supply for "Ger" settlements in major cities needs a proper solution. Smoke from burning coal in "Ger" settlements makes most of the air pollutions creating health concerns and it reaches a crisis level during the winter time.

Due to the absence of a centralized supply system in the rural areas, the low power demand and lack of other energy sources, renewable energies are optimal and even single option for rural electricity supply in most areas of Mongolia. During the last few years, most of the aimag and soum (administration units of

Mongolia) centers were connected to the centralized electricity system through high voltage transmission lines, but it is impossible to cover the whole country. Therefore, developing renewable energy technologies becomes an important issue in energy sector.

Needs for using renewable energies for electricity and heat supply of Mongolia are characterized by followings conditions:

- Mongolia has abundant renewable energy resources
- Supplying rural areas with electricity from the the centralized power system is neither economically feasible nor technically possible due to scarce population in the rural area and low power demand at the end-consumer.
- Supplying rural areas with electricity from the the diesel generators needs constant expenditure of foreign currencies for imported diesel fuel and high cost for transportation due to poor infrastructure, and is sensitive to foreign exchange rates resulting in a high bill for the customers.
- Non-connected soum centers, settlements, tourist camps, border-guard units and custom's offices are still in lack of electricity supply.
- Renewable energy applications are most suitable for the nomadic lifestyle.
- Great differences between daily- base and peak loads, sole reliance on coal-fired thermal power plants and great dependence on imported auxiliary services from Russian grid creates a center of attention for on-grid renewable power generations in order to achiece better dispatching possibilities, better independence of power supply and system stability.

Strategy for development of renewable energy technologies in Mongolia consists of followings:

1. Selection of appropriate renewable energy technologies suitable for Mongolian specific conditions
    - Supplying nomadic households with electricity
    - Supplying small consumers such as SMEs, hospitals, schools and telecommunication offices, etc. with electricity
    - Supplying rural centers with electricity
    - Creating a model configuration for renewable energy hybrid systems (wind-solar-diesel, wind-solar, mini hydro-wind-solar, etc.) for rural electricity supply
2. Commercial renewable energy applications
    - Grid connection of renewable energy systems
3. On-grid renewable energy applications
    - Creation of Integrated Energy System of Mongolia
    - Make grid connection and net-metering available for all renewable power generations

National Renewable Energy Program has targeted to support renewable energy development in Mongolia. The program targeted to increase the share of renewable energy in total energy production by supporting construction of renewable energy power sources in two stages.

In first stage (2005-2010 near term) the country should reach 3-5 percent share of renewable energy in total energy production and 20-25 percent in second stage (2011-2020 long term).

In the first stage of the program, Durgun (12MW) and Taishir (11MW) hydro power plants were constructed, "100000 solar ger" national program was launched and 12 renewable energy systems for soum centers with capacity of 60-150kW were constructed. Furthermore, launching construction of Orkhon (100MW) hydro power plant, making feasibility studies of hydro power plants for future construction, conducting studies of grid connected wind farms and conduction of research in new technologies such as fuel cell, hydrogen power sources, were planned.

In the long term, the program targeted to introduce grid connected wind farms and large scale PV power generating system in Gobi desert area.

Conclusion

- Mongolia has abundant renewable energy resources. More than 1GW of technical potential of hydropower has been identified. The high solar insulation regime covers some 70% of the territory. And more than 160,000km^2 of the land area in Mongolia has been estimated to have good-to-excellent wind potential for utility-scale applications.
- Renewable energy so far plays an important role in two distinct areas: stand-alone electricity supply for nomadic households and off-grid electricity supply for rural centers. Renewable energy (hydro, solar and wind, including home systems) represents about 3% of country's total electricity generating capacity.
- Although renewable are already in use in the country, their potential remains largely unexploited.
- Depending on the technology, application and site, costs of renewable energy applications are generally not competitive (except HPP) with grid/retail electricity or commercial heat/energy production. Its role in grid connected electricity supply is currently negligible but through the new feed-in law the role of renewable energy is expected to increase.A first power purchase agreement was made for 50MW on-grid Wind Park and the project is underway.
- Earlier attempts to disseminate the RE have experienced minimal success due to lack of investments and lack of know-how.
- Capacity building and nurturing domestic private companies is needed for further development of renewable energy.

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