Rural Electrification & Renewable Energy Utilization in Mongolia

Introduction

The Government of Mongolia has identified rural development and rural living standards as having a high priority and acknowledged the drawbacks played by a lack of rural electricity access.

Background

Energy access in rural areas of Mongolia is minimal and delivered services leave much room for improvement. Of the 314 Soum centers, 55% operate diesel generators to satisfy minimal electricity needs: about half do not operate during the summer, continuous operation is carried out by only 13% of the Soum centers during summer and only 34% of the centers during the winter. The remainder operate only at about 2-4 hours per day during the winter. Soum centers are sparsely populated during the summer when herders move to pasture lands, but provide essential services (such as health and education) during the winter when many herders temporarily settle to survive the cold. The systems are owned and operated by the Soum governments and are not financially or operationally sustainable. The main problems are the inability to generate revenues needed to purchase diesel for plant operation and poor institutional capability of operating Soum utilities. The herders have no possibility of getting electricity service other than by an individual supply source.

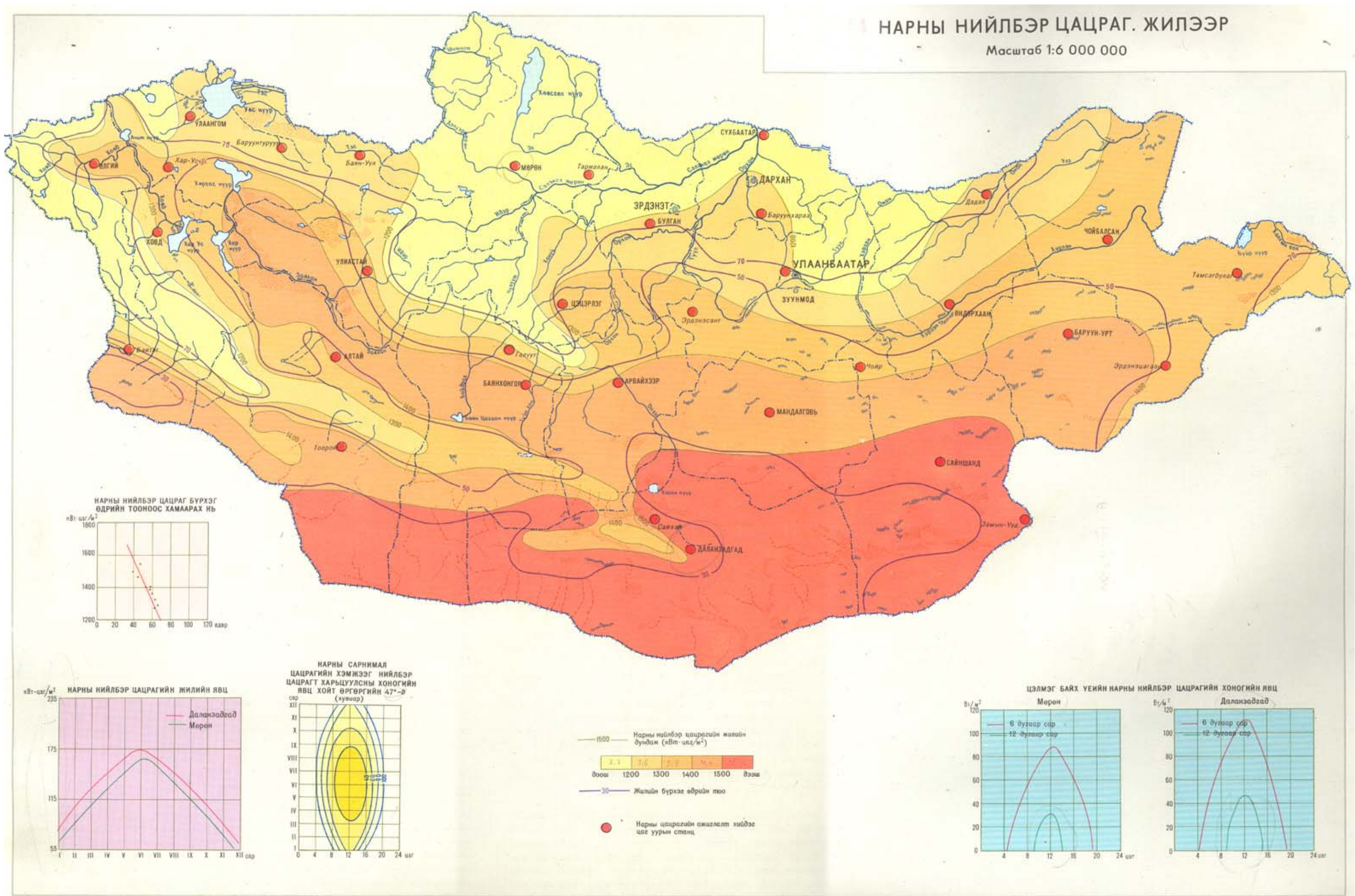
Under such conditions, cost recovery and maintenance of investments in conventional electricity supply infrastructure have proven to be difficult and alternative delivery mechanisms need to be looked at. It is expected that a combination of institutional reforms, establishing public-private partnerships, and the expanded use of renewable energy will greatly improve living conditions of the rural population as well as improve the delivery of rural services.

Assessment of Renewable Energy for Remote Areas

Solar Resource

Mongolia has a very good solar resource. In summer, solar irradiance is in the range of 5.5 - 6.0 kWh/m^2 per day for about 71% of the total land area of Mongolia, with 2,900 - 3,000 sunshine hours per year. The following Fig. shows radiation data for a number of different locations in Mongolia.

SOLAR ENERGY RESOURCE OF MONGOLIA



Annual global solar radiation, kWh / m^2

Daily (Wh/m^{2}day) and annual (kWh/m^{2}year) global solar radiation on horizontal plane (measured value)

Meteorological station	1	2	3	4	5	6	7	8	9	10	11	12	Year
1. Gurvan Tes	2068	3051	4250	5301	6090	5905	5330	5026	4471	3398	2301	1740	1489
2. Dalanzadgad	2415	3479	4699	5802	6629	6692	5778	5377	4963	3815	2577	1982	1650
3. khuvsgul	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Saikhan	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Sainshand	1966	3119	4445	5737	6491								
6. Tooroi	2009	3053	4520	5626	6465	6362	6238	5725	4846	3481	2243	1688	1591
7. Bayandelger	-	-	-	-	-	-	-	-	-	-	-	-	-
8. Mandalgovi	1732	2712	3917	4715	5543	5602	5030	4482	4089	3050	1969	1567	1352
9. Baitag	1748	2690	3873	5008	5799	5937	5907	5543	4222	2826	1959	1533	1433
10. Tonkhil	-	-	-	-	-	-	-	-	-	-	-	-	-
11. Altai	1781	2837	4094	4881	5820	5757	5120	4870	4041	3112	2055	1482	1396
12. Baruun-Urt	-	-	-	-	-	-	-	-	-	-	-	-	-
13. Bayankhongor	1750	2969	4306	5305	6112	6094	5791	4974	4455	3219	2102	1514	1479
14. Khujirt	-	-	-	-	-	-	-	-	-	-	-	-	-
15. Tsetserleg	1632	2826	4075	4925	5547	5238	4801	4275	3797	2694	1979	1372	1313
16. Khalkh gol	1672	2898	4025	4761	5327	5581	5144	4686	3989	2921	1841	1321	1344
17. Zuunmod	-	-	-	-	-	-	-	-	-	-	-	-	-
18. Uliastai	1724	2881	4250	5114	5774	5839	5322	5326	4211	3004	1914	1394	1410
19. Amgalan	1468	2318	3675	4158	5430	5129	4317	4275	3698	2642	1724	1226	1220

20. Ulaanbaatar	1557	2685	4075	5024	6000	6045	5259	4708	4012	2890	1884	1278	1383
21. Terelj	1653	2697	3986	5020	5626	5450	4189	4180	3939	2870	1846	1316	1301
22. Khovd	-	-	-	-	-	-	-	-	-	-	-	-	-
23. Choibalsan	1676	2767	3933	4638	5560	5563	5200	4579	3810	2856	1890	1361	1334
24. Ugtaal	-	-	-	-	-	-	-	-	-	-	-	-	-
25. Yalalt	-	-	-	-	-	-	-	-	-	-	-	-	-
26. Bulgan	1352	2256	3137	3719	4688	4644	3980	3697	3142	2401	1600	1149	1088
27. Zuunkharaa	1593	2506	3767	4375	5278	5346	4381	4213	3479	2508	1548	1262	1225
28. Ulgii	1399	2809	3712	4756	5541	5708	5280	4861	3919	2704	1655	1157	1324
29. Dadal	-	-	-	-	-	-	-	-	-	-	-	-	-
3Î. Erdenet	-	-	-	-	-	-	-	-	-	-	-	-	-
31. Khutag	-	-	-	-	-	-	-	-	-	-	-	-	-
32. Darkhan	1356	2464	3747	4661	5805	5647	4611	3941	3205	2066	1344	934	1211
33. Murun	1343	2432	3742	4777	5528	5683	5082	4597	3796	2646	1588	1097	1288
34. ulaangom	1293	2425	3974	4980	5872	6238	5557	4831	3802	2471	1353	966	1333
35. Shaamar	-	-	-	-	-	-	-	-	-	-	-	-	-
36. Khatgal	-	-	-	-	-	-	-	-	-	-	-	-	-

Daily and annual solar radiation duration, hour (measured value)

Meteorological station	1	2	3	4	5	6	7	8	9	10	11	12	Year
1. Gurvan Tes	241.2	234.1	276.7	293.9	336.6	328.6	330.3	319.9	298.1	281.1	244.1	224.3	3409.1
2. Dalanzadgad	227.0	220.1	257.1	259.2	314.1	313.9	302.8	297.4	285.4	272.2	229.1	217.1	3195.4
3. khuvsgul	222.0	224.9	256.6	265.8	309.4	317.3	321.8	305.9	293.1	270.7	221.6	210.1	3229.6

4. Saikhan	221.6	218.2	252.1	260.7	304.4	304.8	302.3	319.1	295.9	271.2	222.7	208.5	3185.5
5. Sainshand	217.8	219.0	274.8	277.2	308.7	308.9	311.0	286.7	282.9	263.9	219.0	203.0	3173.1
6. Tooroi	197.7	213.2	257.7	267.1	304.9	297.2	318.1	311.3	283.6	259.0	202.6	178.5	3107.0
7. Bayandelger	211.4	222.4	276.3	272.4	310.2	322.6	315.5	296.7	276.6	250.4	212.4	195.2	3162.1
8. Mandalgovi	210.5	223.4	273.4	263.7	300.7	297.6	292.5	285.9	279.7	258.0	210.9	201.8	3110.1
9. Baitag	201.4	215.4	273.2	294.6	333.0	341.8	352.1	333.3	255.7	251.2	200.3	178.0	3257.5
10. Tonkhil	206.7	207.7	271.5	256.9	294.5	263.0	285.9	276.3	264.5	241.4	205.9	193.3	2949.8
11. Altai	201.1	208.3	252.5	260.6	308.9	298.5	293.2	290.2	272.4	246.1	199.6	184.8	3015.9
12. Baruun-Urt	203.3	216.4	263.5	274.6	304.5	303.0	203.9	290.1	280.0	245.2	203.2	183.2	3071.2
13. Bayankhongor	260.5	223.7	271.5	275.1	320.1	309.6	308.8	293.2	280.8	261.7	220.6	205.4	3281.0
14. Khujirt	196.4	210.7	261.5	252.9	233.0	272.8	260.4	250.0	250.3	238.5	196.0	172.3	2848.6
15. Tsetserleg	185.7	197.2	250.2	245.6	279.6	275.4	265.2	260.3	254.0	232.5	186.6	172.6	2805.1
16. Khalkh gol	191.5	208.8	261.7	260.4	292.2	294.4	287.1	285.4	245.7	235.0	185.1	162.7	2911.0
17. Zuunmod	203.1	204.8	267.1	269.4	309.6	295.0	277.7	268.6	256.4	235.7	197.1	175.2	2959.7
18. Uliastai	186.6	204.8	260.7	266.3	341.4	302.1	291.3	288.9	26 .3	223.6	174.0	166.2	2942.2
19. Amgalan	158.4	194.2	264.8	281.4	277.4	286.3	280.3	263.1	246.3	200.2	188.1	157.0	2796.0
20. Ulaanbaatar	176.1	204.8	265.2	262.5	299.3	269.0	249.3	258.3	245.7	227.5	177.4	156.4	2791.5
21. Terelj	189.4	199.1	257.3	277.4	297.0	279.8	255.4	218.5	235.0	214.9	183.8	171.6	2779.2
22. Khovd	171.6	196.3	255.2	266.8	300.4	300.1	366.1	298.0	269.7	236.9	180.3	151.0	2922.4
23. Choibalsan	198.5	212.0	266.1	264.0	294.9	307.3	297.9	287.1	258.2	239.2	199.5	177.6	3002.3
24. Ugtaal	182.0	196.9	264.5	262.5	312.6	284.1	277.8	258.9	249.0	200.5	173.0	131.7	2843.5
25. Yalalt	177.6	196.7	253.6	267.0	307.1	298.6	297.6	293.4	261.4	216.7	177.2	155.0	2901.9
26. Bulgan	164.4	195.5	257.3	256.8	281.8	268.6	259.2	257.8	228.1	215.0	160.4	143.8	2688.7
27. Zuunkharaa	165.5	183.6	227.3	209.7	270.2	272.1	241.0	259.2	212.5	201.7	161.0	135.4	2539.5

28. Ulgii	164.4	187.7	255.1	267.3	231.5	302.6	319.6	302.6	262.3	221.9	172.6	147.7	2925.2
29. Dadal	193.7	211.5	267.3	268.4	292.6	273.0	255.2	251.4	241.6	228.5	136.4	165.9	2835.5
3Î. Erdenet	182.9	196.9	243.3	250.9	290.2	276.9	257.9	255.4	234.8	209.6	172.6	162.8	2735.9
31. Khutag	183.2	163.7	255.3	249.9	291.2	283.7	263.0	261.7	245.8	222.0	173.2	157.4	2790.1
32. Darkhan	166.8	194.8	263.3	275.2	314.8	287.5	269.2	258.3	253.6	214.7	177.2	145.2	2824.6
33. Murun	168.4	189.0	252.6	256.5	294.5	291.5	274.3	274.1	249.0	224.9	168.1	154.4	2797.3
34. ulaangom	135.0	158.4	133.9	260.8	313.4	318.9	307.4	297.2	250.4	295.9	100.5	103.6	2675.4
35. Shaamar	167.4	186.9	241.9	233.9	282.0	276.6	255.5	249.4	230.3	201.8	257.5	232.6	2615.8
36. Khatgal	184.0	204.9	269.6	277.6	309.9	290.6	264.5	258.7	242.6	224.0	176.5	160.7	2863.6

Wind Energy Resource Atlas of Mongolia

The wind energy resource atlas of Mongolia identifies the wind characteristics and the distribution of the wind resource in Mongolia. The information contained in the atlas is necessary to facilitate the use of wind energy technologies, both for utility-scale power generation and off-grid wind energy applications.

The values on the wind resource maps in the atlas are based on the estimated wind power density, at 30 m above ground level, not wind speed. Wind power density is a better indicator of the available resource than the average wind speed. Six wind power classifications, based on ranges of wind power density, were used in the atlas. Each of the classifications was defined for two categories: utility-scale applications and rural power applications (ranging from moderate to excellent). In this atlas, the 30-m height was chosen as a compromise hub height between large utility-scale wind turbines (primarily between 30m and 80m) and small wind turbines (generally between 10m and 30m) used for rural power applications.

In general, locations with an annual average wind resource greater than 300W/m^2 or 6.4m/s at turbine hub height are the most suitable for utility grid-connected wind energy systems. Rural or village power applications can be viable at locations with a wind resource as low as 100W/m^2 or 4.5m/s.

Wind Power Classification

Class	Resource Potential		Wind Power Density at 30 m agl (W/m^2)	Wind Speed at 30m agl (m/s)
	Utility	Rural		
1	Marginal	Moderate	100 - 200	4.5 – 5.6
2	Moderate	Good	200 - 300	5.6 – 6.4
3	Good	Excellent	300 - 400	6.4 – 7.1
4	Excellent	Excellent	400 - 600	7.1 – 8.1
5	Excellent	Excellent	600 - 800	8.1 – 8.9
6	Excellent	Excellent	800 -1000	8.9 – 9.6

Throughout the plains of central and eastern Mongolia there are significant areas of good-to-excellent wind resource, especially for rural power applications. The provinces with the most extensive areas of suitable resource are Umnugovi, Dundgovi, Dornogovi, and Sukhbaatar. The level of resource at a particular site on the plains is primarily influenced by its elevation relative to the surrounding area and the terrain upwind and downwind of the site.

Complex terrain consisting of large mountain ranges separated by valleys, plains, and basins dominates the topography of north-central Mongolia and all of Mongolia west of 105^{o}E longitude.

The distribution of the wind resource in the complex terrain is much more varied than the distribution of the wind resource on the plains, but a few general features still can be noted. Exposed ridge-top locations have the highest resource levels in Mongolia. At these sites, the wind power density can be greater than 600 W/m^2. These are the sites most directly influenced by the strong westerly jet stream. However, the resource can vary widely along the ridge crests, and the highest resource areas are generally scattered throughout the mountainous regions. The distribution of the wind resource in the valleys, plains, and basins of western Mongolia varies. In general, the wind resource is lower in the western third of Mongolia as compared to the rest of the country. The most extensive areas of lower elevation with moderate-to-good/excellent wind resource in western Mongolia extend from Umnugovi westward through southern Bayankhongor, southern Govi-Altai, and into extreme eastern Khovd. Finally, some mountain passes and corridors between terrain features may possess good-to-excellent resources. The prevailing wind at the higher wind resource sites in Mongolia is generally from a westerly or northwesterly direction.

There are large seasonal variations in the wind resource throughout Mongolia. Most of the lower elevation regions in Mongolia have maximum wind resource potential from March through June, with April and May being the windiest months. The wind resource decreases rapidly after this period, resulting in lower elevation areas having a wind resource minimum in July and August. The wind resource distribution for the period from October through February is more complex. Some locations show a secondary wind resource maximum in October and November and a decrease in the resource from December through February before the primary resource maximum in the spring. A few lower-elevation locations have a winter (December through February) or autumn (October and November) wind resource maximum. Acceleration of the wind flow around local topographic features is the likely primary factor in creating these special seasonal wind resource patterns.

The seasonal wind resource distribution on ridge-crest locations varies from eastern and central Mongolia to western Mongolia. The eastern and central ridge-crest locations have a similar seasonal distribution of the wind resource to sites in the plains and other low-elevation areas. The resource reaches a maximum in April and May, has a secondary maximum in October and November, and is at a minimum in July and August. The seasonal wind resource on ridge crests in western Mongolia is different. The western Mongolia ridge crests have the maximum resource from October through December with a secondary maximum occurring in April and May. The minimum resource is during July and August.

The diurnal wind speed distribution, or wind speed versus time of day, is strongly influenced by site elevation and topography. The distribution at low-elevation sites in simple terrain on the plains typically features a maximum wind speed during the afternoon and a minimum near sunrise. Ridge-crest diurnal distributions differ from those of low-elevation sites. The strongest winds at ridge-crest locations occur at night while the lowest speeds are observed during the midday hours. Sites located in complex terrain and subject to wind flows caused by local conditions can have a diurnal pattern different from either the simple terrain of the plains or the ridge crests. Table 1and 2 give details of the wind resource at 30m.

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 1: 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

Wind speeds are based on a Weibull k value of 1.8 and an elevation of 1400m

More than 160,000 km^2 of windy land areas in Mongolia have 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 (1,565,000 km^2) of the country. This amount of windy land, using conservative assumptions that result in about 7 MW of capacity per km^2, could support over 1,100,000 MW of installed capacity, and potentially deliver over 2.5 trillion kWh per year. All of the provinces have at least 6,000 MW of wind potential. There are 13 provinces that have at least 20,000 MW of wind potential, and 9 provinces 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 for rural power applications) are considered, the estimated total windy land area increases to more than 620,000 km2, 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 provinces with at least 50,000 MW, 12 provinces with at least 100,000 MW, and 9 provinces with at least 200,000 MW of wind potential.

Hydro Power Resource

Mongolia's hydroelectric capacity resource is 6417.7 MW and it is possible to produce 56.2 billion kWh electricity with hydro energy annually. It is possible to build and operate hydroelectric power stations with total capacity of over 700 MW in short and mid-term in the Western and Khangai regions.

Mongolia has significant hydro power potential. There are currently five small hydro plants in operation, providing electricity to neighbouring areas. Their installed capacity ranges from 150 kW to 2 MW[1]. There are plans for further hydro plants. In remote areas, a hydro plant would typically supply several neighbouring Soum Centres. There are also plans for hydro plants connected to the electricity grid. The main aims of these schemes are to replace conventional fuel or to provide power during peak demand and thereby eliminate the need for electricity imports from Russia.

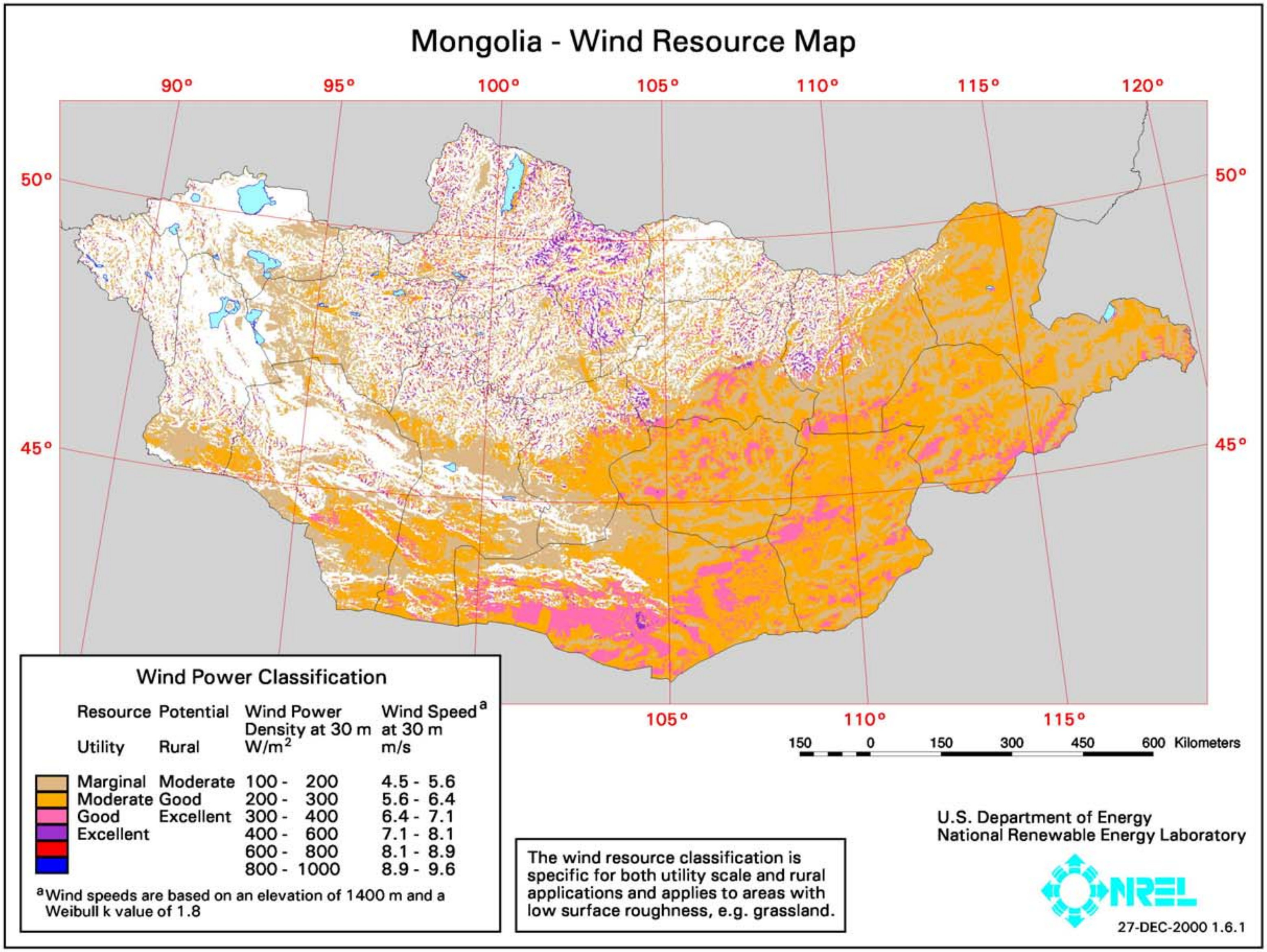

Mongolia - Wind Resource Map
90°
95°
100°
105°
110°
115°
120°
50°
45°
Wind Power Classification
Resource Potential
Utility Rural
Wind Power Density at 30 m W/m²
Wind Speed a at 30 m m/s
Marginal Moderate 100 - 200 4.5 - 5.6
Moderate Good 200 - 300 5.6 - 6.4
Good Excellent 300 - 400 6.4 - 7.1
Excellent 400 - 600 7.1 - 8.1
600 - 800 8.1 - 8.9
800 - 1000 8.9 - 9.6
a Wind speeds are based on an elevation of 1400 m and a Weibull k value of 1.8
The wind resource classification is specific for both utility scale and rural applications and applies to areas with low surface roughness, e.g. grassland.
150 0 150 300 450 600 Kilometers
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
27-DEC-2000 1.6.1

Figure 6-1

Geothermal Energy Resources

According to a geophysical study, Mongolia has about 42 small hot springs in Khangai, Khentii, Khuvsgul, Mongolian Altai mountains, Dornod-Darigangiin steppe and Orhon-Selenge region. The average underground heat flow at the hot springs of the Khangai Mountains is about 52±6 MW/m2, in the Khuvsgul lake region 80±10MW/m2, in the Mongol Altai Mountain region 54±24MW/m2 and in the Dornod Mongolia steppe 44±6MW/m2. From International experience, it is possible to use hot water and hot stream from underground 3000 m depth.

The Geothermal study has two steps: 1) Geophysical and 2) Geochemical part. And underground temperature distribution calculated by Schlumberger's method. NEDO (Japan 1997) recommended to take up two projects of geothermal power plants at the Chuluut hot spring area (Arkhangai Aimag) and Shaargaljuut hot spring area (Bayanhongor Aimag). According to this application document, hot water of 45 ° C and 90 ° C is available Chuluut and Shargaljuut respectively. Tsenher and Shargaljuut's hot springs are used at present for heating the rest house and the greenhouses. If further investigations confirm the availability of larger power potential 1-3 MW, supplying power to Bayanhongor would be a viable option

for the future. More details material for geothermal energy resource in Mongolia is available in the geological fond. There are geophysical data and feasibility studies for the Hangai mountain region. Also Energy magazine has some kind of geothermal material. Mr. Namnandorj's book on Mineral water resource of Mongolia includes material about hot springs.

Estimated Heat Resources of Khangai Geotherm System

Subsystem	Natural resources, m^3/day	Energy resources,MW
Tarbagatai-Uliastai	3127,6	15-200
Baidrag –Tamir	2332,8	10-200
Orkhon-Taats	10961,8	20-500
Total	16422,2	45-900

Source: Final Report TA 3299-MON Capacity Building in Energy Planning, ADB

Socio-Economic Situation in Mongolian Rural Villages (Soums)

(1) Administration

During the period from the independence in 1921 to the collapse of the Soviet Union in 1990, Mongolia was under the socialist system. The current local administrative system of Aimag-soum was established in the socialist period.

The local administration basically takes a centralized form and forms such a hierarchy that with the central government on the top there are 21 aimags, counterpart to the Japanese provinces, and under the aimags there are soums ranging in number from 10 to 20.

Local administrative budget is financed by subsidies from the central government and taxes collected by aimags and soums. Among those local taxes included are: real estate tax, water resources tax, vehicle tax, inheritance tax, gun tax, royalty tax and hunting tax. National taxes include corporate tax, personal income tax, customs duties, petroleum goods tax and value-added tax. As for corporate tax, soums collect tax from small-size enterprises. The taxes collected by soums cannot afford their administrative costs so that the major part of their budget is subsidized by the central government or aimags.

(2) Economy

The key industry of rural soums is livestock farming. In the soum centers, which have an administrative function, there are small-size manufactures such as clothing, shoes and bakery as well as commerce. Farming of vegetables for the soums is practiced. The commerce is of a small scale by personal shops, which make purchases from Ulaanbaatar, Aimag centers and the neighboring countries such as China and Russia.

Regarding BHN and infrastructure for living and economic foundations, the soum centers at least have scarce but minimum infrastructures, which were once supported by the former Soviet Union during the socialist period. However, those infrastructures are not fully utilized because of shortage in fund to purchase fuel.

(3) Utilities

Potable water basically comes from wells or rivers where there are rivers. Heating in the winter is indispensable for living because the temperature goes down to minus 30℃. Public facilities are centrally heated on their own and households are heated by coal stoves. During the socialist period, public facilities used to be heated by central heating for the whole soum center but not for the present time.

Power used to be supplied for 24 hours a day during the socialist period. Since 1991, shortage of fuel fund has only allowed power supply by diesel generator in the soum centers for 4 to 5 hours a day from October to May.

(4) Communications

Roads, which are necessary for logistics and personal exchanges, have rarely been well paved and traffic uses wheel ruts in grasslands and mountain areas except for some sections, costing considerable time. Air traffic is available from Ulaanbaatar to major Aimag centers with a weekly flight. Regarding telecommunications, each soum center has a telecommunications center to provide telephone services, national and international. There are few households which have telephone. In Aimag centers, mobile phones can be used to make calls to major cities and other Aimag centers.

(5) Medical Care

Each soum has a clinic, which is equipped with the minimum necessary apparatus and medicine for primary care and medical treatment for mild cases; and, however, there are only one or some doctors and several nurses, which are not enough. Patients needing operations or higher treatment will be transferred to a hospital in an Aimag center. Even if the soum clinic is equipped with surgical equipment, such equipment cannot be used because of no power supply for 24 hours a day. A refrigerator to store vaccine must be powered by a small engine generators and the clinic must manage to raise the necessary fund for the fuel from its scarce budget. Some clinics do not have a refrigerator for vaccine. The operating costs of the clinic including treatment expenses are funded by budgetary allocation from the Ministry of Health.

(6) Education

Rural people are education-minded and school enrolment rate is high. Each soum has kindergarten, primary school, junior high school and senior high school. Many students go to college, junior college or vocational school after graduating from high school. Tuition is free for students under the age of 18. Children of herdsmen are sent to a school boarding house in the soum center when the school is open, while a number of their mothers accompany them and stay in the soum center. That fact increase the number of households and population of the soum center in the winter. Schools, boarding houses and kindergarten are provided with budgetary allocation for their operation by the Ministry of Education.

Situation of Power Sector

(1) Power Sector Structure

Power sector of Mongolia is currently operated by state-owned enterprises under supervision of Ministry of Infrastructure. There are three main power grids: Central Energy System linking Ulaanbaatar capital of the country, Darkhan iron-making city, Erdenet copper-mining city, Baganuur coal-mining city; East Energy System centered in Choibalsan; Western Energy System with constant supply from Russia. In all of those systems, state-owned enterprises engage in power and heat supply business. Rural areas which are not connected with those systems have publicly-operated diesel power stations in Aimags and Soums. The above three power grids are not interconnected.

In Central Energy System, the largest power grid, there are Thermal Power Plant No.2 (21.5 MW), Thermal Power Plant No.3 (148 MW), and Thermal Power Plant No.4 (540 MW) in Ulaanbaatar, supplying power and heat. There are Darkhan Power Plant (48 MW) in Darkhan, Erdenet Power Plant (28.8 MW) in Erdenet. Total installed capacity of Central Energy System is 786.3 MW.

East Energy System has Choibalsan Power Plant (36 MW), while Western Energy System is supplied with electricity from Russia, keeping a diesel power on standby for emergency. Total installed capacity of Mongolia is 828.3 MW including Dalandzadgad Power Plant (6 MW) commissioned in 2000 in southern Gobi region.

All of the power plants in the three main power grids are coal-fired using domestic coal. Heavy oil used for startup of power plants and diesel oil used for diesel power plants entirely come from Russia. As coal-fired power plants have a limited ability to follow load, Central Energy System imports electricity from Russia to meet peak demand.

(2) Power Sector Reform

The government of Mongolia has been engaged in power sector reform for long years as part of market-oriented economic reform. Some structural reforms have so far been made and the New Energy Law enacted in April, 2001 makes clear unbundling of generation, transmission, distribution, dispatch, and supply and makes compulsory acquisition of a license for each specified business. The Law also creates Energy Regulatory Authority (ERA), actually established in June of the same year, replacing Energy Authority (EA) to take charge of supervision and regulation of the power and heat sector. Besides, the Law has made independent state-owned enterprises of generation and distribution, which had been administered by EA, and established dispatch and transmission business concerns as National Dispatching Center and Transmission company.

In August, 2001, a decree was issued to corporatize 18 state-owned enterprises in the energy sector. Thus, it can be said that prima facie, legal and structural grounds have been established with a view to market-oriented reform. At the same time, the government owns the whole of the shares of those corporations so that there remains a major issue about how much independence of management the new corporations can acquire on account of their character of government-owned joint stock company. In rural areas as well, diesel power plants of Aimag centers have been corporatized but are currently wholly owned by the central government, while power supply in soums are operated by virtually public management of the soum centers.

About half of Mongolia's population are nomadic people, who for health, education and other basic services depend on an administrative centre (small town), called the Soum. Of the 340 Soum Centres only 117 are connected to the grid and the reliability of electricity supply is poor. Off-grid Soums operate small diesel generators but typically only for 2-5 hours each day and many are not used in the summer. The diesels are plagued with operation and maintenance problems that hamper the success of poverty reduction programmes in health, education and municipal services. However, given abundant solar and wind resources and the remoteness of these areas, the potential to benefit from renewable energy in an economic and reliable way is significant. The rural areas are vital to the country's economy, supplying food and raw materials to the cities. Hence the provision of reliable renewable energy supplies, where economically justified, will support Mongolia’s development and be in synergy with the Millennium Development Goals.

Socio-Economic Status and National & Rural Development Plans of Mongolia

According to the statistics, 54% of Mongolia's population lives in urban areas, leaving approximately 1.6 million Mongolians living in provincial or more rural areas (2000). It is forecast that by 2020 the percentage of Mongolians living in urban areas would have increased to only 58%, meaning that a significant portion of the population will still be in provincial and rural areas and will benefit from the expansion and development of the rural telecommunications system in rural areas outlined in the Study. As opposed to Ulaanbaatar where immigrants from rural areas have been continuously absorbed, population of urban areas mostly decreased until 1997 while rural population has constantly increased till 1997. Annual growth rate in urban areas in Mongolia is 0.9% as total urban population in the past decade (1990-2000). By contrast, the population growth rate for rural areas for the same period has been 2.2%.

Situation on National Grid Extension to Rural Villages

Latest information on the rural village electrification by national grids given by Ministry of Fuel and Energy (MoFE) is summarized in **Attachment 1 and 2**.

Attachment 1 shows not only electric power supply situations of soums but general information such as population, number of households.

Attachment 2 shows the current situation on national grid extension to soums, which clearly represents zoning of off-grid soums in Mongolian territory. Most of off-grid soums are located in the southern part and mountainous part of Mongolia and far from the existing tie-in point of the national grids

The 100,000 Solar Ger Programme

The Mongolian government's National Programme *100,000 Solar Gers* was adopted in 1999. The programme was geared at assisting nomadic livestock herders, rural schools, hospitals and government agencies to have access to electricity and is to run from 2001-2004. The Programme was established under the Ministry of Infrastructure.

The objectives of the Programme were:

- Development of solar power systems to meet basic electricity demand of livestock herdsmen's households
- Provision of solar home systems for all rural households, hospitals and schools in Mongolia.

The activities undertaken in this programme are as follows:

- Development of solar power system in order to meet the basic electricity demands of livestock herders and their households. This demand is essentially for enough electricity to run lights, listen to radios, watch televisions, use computers and other media of communication.
- Provision of solar home systems to all rural households.

The benefits of this programme are calculated as follows:

- Ultimately, 100,000 nomadic families, rural schools and hospitals and government agencies will all be provided with a small capacity solar home system which will allow them to have light and various other appliances.

Experience of Renewable Energy and Rural Electrification in Mongolia

The first renewable energy which was utilized in Mongolia was hydropower. Kharhorin hydropower station (528kW) was constructed in 1959 with assistance form the former Soviet Union and is currently still in operation. There other 4 small-size hydropower stations, adding to a total installed hydropower capacity of 3MW. Most of the hydropower stations are in operation only during the summer because of frozen rivers during the winter. In 2001, a 2-MW hydropower station was constructed in Zavkhan Aimag but is currently out of service because of damage to the water channel.

In planning are Taishir hydropower (8MW) in Govi-Altai and Chargate hydropower (8MW) in Khövskhöl Aimag. Some large-scale hydropower stations – Egiin (220MW) and Orkhon (100MW) – were planned but their implementation is not yet in sight because of difficulties in financing.

Stage of Commencement (1970-1987)

Primary research and practical works to exploit renewable energy recourses was conducted in Mongolia by physicists and energy engineers of the Institute of Physics and Technology of the Mongolian Academy of Sciences and the Mongolian Technical University from the early 1970's.

UNDP commenced co-operation in renewable energy 1975 with Project MON/75/006 "Demonstration of New Sources of Energy in Rural Development" in which two solar pumps, wind pumps, and 35 small (6Wp) photovoltaic lighting systems were demonstrated in the period 1979-1983. In addition a medical centre was equipped with a solar powered vaccine refrigerator and lighting system. Following satisfactory results of this project UNDP supported two additional projects MON/86/005 "Complex use of Renewable Sources of Energy" and MON/86/006 "Development of Photovoltaic Cells". The first of these two projects evaluated further renewable energy technologies including small wind-generators, solar thermal systems, solar photovoltaic (PV) systems and biogas plants.

The activities supported by UNDP included an assessment of the potential market for PV systems in Mongolia (carried out by IT Power in 1990 and assessed as 5.2 MWp). The project also facilitated a joint venture ("Monmar") between UK company Marlec Ltd and the Government of Mongolia for the manufacture of small 50W wind turbines for nomadic herding families. This joint venture also received technical support from UNIDO.

UNDP project Mon/86/006 provided support to the Institute of Physics and Technology (IPT) in their pioneering work on photovoltaic cell and module manufacture for portable power for nomadic herding families. This resulted in the laboratory production of PV cells of more than 13% efficiency.

As a result of the pioneering work of IPT and the Academy of Sciences in the 1970's and early 1980's, the potential use of solar energy in Mongolia was accepted by the government as well as by the public and the background to the utilisation of renewable energy was established.

Stage of Experimental Use (since 1987)

The strategy of electrification of small consumers in Mongolian rural areas was declared in governmental policies. This strategy was implemented by expanding research activities, transfer of know-how from developed countries, establishing small-to-medium enterprises and producing equipment with the intention to provide nomadic families and small consumers with electricity, by using renewable energy technologies such as biogas, hydro, solar and wind energy.

Enterprises of small-sized solar and wind energy systems for nomadic families were established, a number of national or international projects were implemented and professional institutions were established, namely the Renewable Energy Corporation, a PV manufacturing plant and a wind turbine manufacturing plant. Hydro power plants were built to supply Soum Centres with electricity. Renewable energy is regarded as one of the main sources to supply small localised centres in rural areas, villages and nomadic families with electricity, which have not yet been connected to centralised electricity network.

- The Renewable Energy Corporation was established as an organisation responsible for scientific research and production activities for the utilisation of renewable energy, applied research and experimental and demonstration projects for the utilisation of solar, wind, hydro and biomass energy in Mongolia.
- Monmar was established for the manufacture of small wind generators for nomadic families
- The EU supported PV technology transfer from Soltech (Belgium) to ABE (Mongolia)
- A hydro power plant on the Chigj River was built.
- More than 2000 PV lighting systems were imported by the Ministry of Energy, Mining and Minerals, modified to allow power for radios and distributed to nomadic herding families.
- A PV manufacturing plant was built within the Ministry of Telecommunications with support form ADB.
- Japan supported the demonstration of portable 200Wp PV systmes and wind and solar monitoring
- A hydro power plant on Bogd River, with a capacity of 2,000 kW was built and connected to Uliastai town with 35 kV electricity transmission line.
- A hydro power plant on Tugrug River in Mankhan soum, Khovd province was built.

- A hydro power plant on Guulin Channel in Govi-Altai province was built and Guulin and Shiluustei Soum centers supplied with electricity.

Stage of Commercial Use (since 2000)

The National Programmes *100,000 Solar Gers* and *Integrated Energy Systems* were affirmed by the Mongolian government, and domestic and foreign investments were increased in order to execute the programmes. The objectives regarding the development of renewable energy utilisation as declared in the National Programme *Integrated Energy Systems, as well as in the National Renewable Energy programmes.*

Overview of National and International Mongolian RE Projects

Table 1 and Table 2 below give an overview of past national and international Mongolian renewable energy projects.

Table 1: National Renewable Energy Projects

Name of projects	Ordered and implemented by	Results
Sophisticated utilisation of the solar and wind energy in the state economy, construction of equipment and plants (1989-1990)	MoI REC	The solar collector, biogas digester, movable type of wind generator were constructed and tested.
Solar energy (1991-1993)	MoI REC	Greenhouse and solar collector were constructed and tested. The renewable energy testing field was built.
Biogas (1991-1993)	MoI REC	100m^3 biogas digester was constructed.
Wind energy (1991-1993)	MoI NREC	Wind energy measurement in Manlai soum, Umnugovi province.
Electrical chemistry (1991-1993)	MoI NREC	Techno-economical feasibility study on the accumulator manufacturing plant was carried out. Production technology of accumulator was chosen.
Solar and wind energy (1994-1996)	MoI NREC	Alternative ways to provide herdsmen families with electricity, using renewable energy technologies, were developed and tested under real conditions.
Production technology of biogas and bio fertilizer based on cattle-breeding wastes, inventing and disseminating some equipment and plant (1994-1996)	MoI NREC	Production technology of bio fertilizer and briquettes was developed, using sludge from a biogas digester.
Utilisation technology of hydro energy of Mongolian small rivers as energy sources for small consumers (1996-1999)	MoI NREC	Design of a portable type of hydro power plant (HPP) with a capacity of 1 kW. Review plan of utilisation of hydro energy on 12 rivers.
Assessment of solar and wind energy resource in Mongolia and technology of its utilisation (1997-1999)	MoI NREC	Assessment of solar and wind energy resource in Mongolia was determined and map of resource was produced. The further development plan of renewable energy utilisation in Mongolia was produced. Drawing of solar house was produced.
Production technology of biogas and bio fertilizer, based on hot spring (1997-1999)	MoI NREC	Map of the possibility of production of biogas and bio fertilizer in hot spring region was produced.
Small scaled electricity generating solar-wind hybrid system (1999-2000)	MoI NREC	Selection of small wind generator that can be used under Mongolian conditions was made. On site experiment of supplying rural small users with solar and wind energy.
Study on the provision of herdsmen families with electricity, communication and information (2002-2003)	MoI NREC	Inputs to 100,000 Ger Programme
Study on possibilities to build wind farm with capacity of 25-30MW (2002-2003)	MoI NREC	Potential for Wind farm identified
Using vacuum collector in solar bathhouse in soum centre (2002-2003)	MoI NREC	Technology demonstrated
Improved channels for reservoirs and rural development (2002-2003)	MoI NREC	Techniques developed
Energy supply for some techniques and equipments in military tactical units (2003-2004)	MoI NREC	Application of renewable energy

Table 2: International Projects

Name of projects	Implemented and supported by	Results
Demonstration of New Sources of Energy in Rural Development MON/75/006	UNDP Academy of Sciences	Solar and Wind technologies demonstrated Government and public support developed
Applied research and development for rural use of renewable energy MON 86/005 (1986-1990)	UNDP REC	Wind generator factory Renewable energy laboratory
Development of Photovoltaic Cells MON/86/006 (1986-1990)	UNDP IPT	PV Cell and Module manufacturing expertise developed
Transfer of Technology for the Production of PV Cells and Modules (1991)	EU Soltech/ABE	Transfer of PV Module Laminators for commercial) PV module production (now discontinued)
Research of portable type photovoltaic power generation system for demonstration (1992-1997)	NEDO REC	On-site experiment and test of 3 types of 200 Wp PV systems for herdsmen families in all areas of Mongolia
Technical Assistance on Wind Generator Manufacture	UNIDO Monmar	Improved Wind Generator Manufacture
Study on the utilisation of solar and wind energy in Mongolian rural areas (1992-1993)	DANIDA	Study and advice on electrification of Bag center and local centers using renewable energies
Photovoltaic manufacturing plant (1998)	ADB, HF PTA	Photovoltaic manufacturing plant with annual production capacity of 5 MW_p of PV modules
Rural electrification from renewable energy sources in Mongolia (1998-2000)	TACIS NREC	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 NREC	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
Utilisation of renewable energy in rural area of Mongolia (1999-2007)	GTZ NREC	On site experiment on utilisation of renewable energies in Zavkhan province
Research and experimental project on photovoltaic power plant (2002-2004)	NEDO MoI	Photovoltaic power plant with capacity of 200 kW_p was built in Noyon Soum, Umnugovi province
Rehabilitation of HPP on Bogd River, Zavkhan province (2003-2004)	KfW	Repair work of head-race channel of HPP on Bogd River
Nomadic electrification (2003)	JICA	Distribution of 11,500 PV systems with a capacity of 62 W_p
Erdenebulgan (2003)	DANIDA	Hydro Power Plant with capacity of 200 kW
Development of renewable energies utilisation in rural areas (2003)	ADB	Research project
Hydro Ppower Plant on Eg River	ADB	On-site study of HPP and techno-economical feasibility study, Drafts and blueprints
Construction of Taishir Hydro Power Plant	KF FEA	Drafts and blueprints of HPP on Zavkhan River with capacity of 12MW was made
Study on HPP on Orkhon River	JICA FEA	Techno-economical feasibility study on HPP on Orkhon River with capacity of 100MW

Other Renewable Energy Activities in Mongolia

Activities by GTZ

GTZ is a German government-owned corporation for international co-operation. GTZ have been active in Mongolia for a number of years. Most of their energy-related activities are concentrated in the north-western Aimags Zavkhan and Huvsgol. In addition, GTZ have implemented various capacity building measures. For Zavkhan and Huvsgol Aimags, GTZ have developed a preliminary supply concept. The renewable energy resource in these Aimags was assessed. The first step of the supply concept is the individual supply of single Soum Centres. The next step is the connection of neighbouring Soum Centres to form local grids, followed by interconnection of the local grids.

GTZ are currently building a 375 kW hydro power plant in Tosontsengel. The hydro power plant will later be operated by a private operator. The hydro plant will supply Tosontsengel Soum Centre, and will later be interconnected with neighbouring Soum Centres.

A 6 kW PV-wind hybrid scheme was implemented in Tsagaanchuluut. This is described in more detail below (see section 0). Another small PV-wind hybrid scheme supplies a very remote Bag centre in the west of Zafkhan Aimag. It consists of a 400 W wind turbine and a 200 W PV array. The hybrid system is run by a private operator, and supplies 3-4 families, a primary school and the Bag hospital. A 5 kW PV battery charging station is currently being planned.

Support under the EU TACIS Programme

A project under the EU TACIS Programme (EMON 9601) provided support to the Mongolian energy sector for a) the implementation of an energy conservation programme and rational use in industry, and b) the use of renewable energy sources in isolated rural areas.

The objectives of the project were to assist the Mongolian industry and authorities in the energy savings in both the short and long term by implementing and monitoring a number of cost-effective and representative energy saving pilot and demonstration projects, providing training and public awareness initiatives and establishing joint ventures and to provide the beneficiary with defined and viable RE projects and if possible, to promote RE manufacturing joint ventures.

The project also included three demonstration projects of hybrid wind/PV/diesel power plants of about 5kW in different Soum Centres. The hybrid systems were installed and tested in Soum hospitals and school dormitories. The project lead to better medical service by providing lighting for Soum hospitals. Living condition in dormitories were also improved. About 40 to 80 pupils from herdsmen families living areas some distance from the school live at each dormitory. Experience gained from this project included that the specific weather conditions in Mongolia caused problems for the wind generators. Problems with maintenance and local production of generator parts were also experienced.

Bayan-Ondor (Bayankhongor Aimag)

At this Soum Centre, an 8 kW wind turbine had been installed under the European Commission's TACIS Programme. The wind turbine, which was still operational, only supplied the dormitory and the hospital, and was not connected to the Soum Centre's diesel-powered mini-grid. Electricity from the grid could however be used to charge the battery of the renewable energy system during periods of low wind. Typically, power would be available from 19.00 to 08.00 hours each night. Most lights were only used for about three hours during the evening, and only those lights which were required were left on during the night.

The renewable energy system was located in a room in the dormitory, with the wind generator being adjacent to the building. The school and the hospital were connected via a dedicated cable which was attached to the mini-grid poles.

The main appliances used were lights, typically CFLs with a power consumption of 9-16 W, although one CFL with 35 W was seen. In addition, the dormitory used a TV, and the hospital used a vaccine refrigerator and an operating lamp. A significant number of light fittings without a light bulb or CFL were seen. Staff said that they were able to obtain replacement CFLs, but these were expensive (around 4,500 MNT each). The general condition of both hospital and dormitory suggested that they required some attention.

Boghd (Bayankhongor Aimag)

Here the hospital had a dedicated PV system, which was independent of the Soum Centre's mini-grid. The PV system was small, with an array of approximately 800 W_p.

Initially, there had apparently also been a wind turbine, but this had been removed by the time of the site visit, presumably due to not being operational any more.
The PV system supplied power to appliances such as the breathing apparatus and the vaccine refrigerator during periods when the diesel generator was not operational.

Tsagaanchuluut (Zafkhan Aimag)

In Tsagaanchuluut, GTZ had installed a PV wind hybrid system (5 kW wind and 1 kW_p), which operated in addition to the Soum Centre's diesel-powered mini-grid. GTZ had built an additional grid supplying the institutional buildings and a number of households from the renewable energy hybrid system.

One very interesting feature of the project was the implementation of a private operator model. Whilst the renewable energy system was owned by the Soum administration, operation was carried out by a private operator. Contracts had been put into place between the operator and the Soum administration, as well as with each of the users connected to the system. A committee comprising members from the National Renewable Energy Center and the Aimag administration had been installed to oversee the operation of the renewable energy system and to arbitrate in case of any dispute between the operator and the Soum administration.

Energy efficiency measures had been implemented, and each user's consumption was metered. The price of electricity of 400 MNT/kWh was high, leading to a fairly small electricity consumption. However, even with this high rate a consumer with only a single low-energy light would pay in the order of 1,000 MNT per month, compared to typically 5,000-6,000 MNT per month on a flat rate tariff. This is therefore more equitable. Household consumption ranged from 1.5 to 18 kWh per month. It was assumed that the wide range was due to some households only using a single low-energy light, whilst others had several lights, TV, iron and maybe a refrigerator. 30% of all income from the sale of electricity was put into a savings account for repairs and replacement of components such as the battery. The funds in this account could only be accessed with the agreement of the Committee, to ensure that they are not used for other purposes.

Noyon Soum (Umnugovi Aimag)

This Soum Centre had a 200 kW_p PV system running in parallel with three 100 kVA diesel generators. The PV system was very new and was only inaugurated this September. The project was financed as a demonstration project with Japanese funding through NEDO. Although there were three diesel generators, only one of them was used at any time. This was mainly because the average load was only around 60-70 kW, but may also have been due to lack of funding for diesel fuel. Prior to installation of the PV system, the diesel generator had been operated only for about six hours per day for economic reasons.

It would appear that the sizing of the system was such that the PV system alone could supply the whole of the Soum Centre's electricity demands. However, as the diesel generators had also been funded by the Japanese during the late 1990s, political reasons required that the system was configured as a hybrid system incorporating the diesel generator. Apparently, the battery capacity had been reduced so that the diesel generator was required to operate daily. Due to this arrangement, a significantly smaller PV system would have been sufficient. When the site was visited, it appeared that the diesel generator was programmed to operate from 18.00 to 24.00 hours, with the PV system providing electricity for the remainder of the day. However, this may have been changed subsequently.

The PV generator was split into a number of different arrays in different locations. The main array of 100 kW_p was located near the power centre, which housed the diesel generators and the battery. Smaller arrays were located adjacent to the school (40 kW_p), hospital (40 kW_p), communication centre (10 kW_p) and Soum administration building (10 kW_p). The main array was split into two subarrays, each charging a lead acid battery of 144 two-volt cells and 1000 Ah capacity. Each subarray and battery was connected to the diesel grid via a 50 kW inverter.

Renewable Energy Users

The main institutional RE users in Mongolia are the Mongolian Telecom and the Civil Aviation Authority. Mongolian Telecom have small stand-alone PV systems in most of the communication centres of Soum Centres. The size of the systems is usually about 900 W_p, and consists of 50 W_p modules manufactured locally. The battery size varies from around 100 Ah capacity to a considerably larger battery bank. Typically, the PV systems are not connected to the local mini-grid, although the grid may be used for topping up the batteries. The PV systems supply telecommunications equipment for voice telephony.

Besides of Mongolian Telecom the Civil Aviation Authority also uses PV systems for air traffic control.

Activities of Mongolian Institutions and Enterprises

A number of Mongolian institutions and enterprises was visited to ascertain their activities. This section describes the results of the interviews conducted.

Malchin Wind and Solar Power System Company

Malchin sells 20 W_p and 40 W_p PV modules imported from China. The sales price of the 20 W_p module was 145,000 MNT and the larger 40 W_p module was 260,000 MNT. The larger modules tend to be used for tourist camps which require more energy for refrigerators and lighting rather than in SHS applications. In 2003, Malchin installed a system at 2 tourist camps. Each camp had a hybrid system using 40-50 W_p PV modules (500 modules at each site) and 2 wind turbines of 100 W, and a 2 kW inverter. Malchin also supplied the camps with CFL lights.

In 2003, Malchin installed 650 hybrid systems for herdsmen, 280 of which included installation of a Malchin supplied satellite. These 280 systems used 40-50 W_p PV modules whereas those without satellites used 20 W_p modules. Home systems had a 100 W turbine at each home. Wind turbines used by Malchin were purchased from Shandong province in China for 2,000 CNY (250 USD or 250,000 MNT). Malchin sells them in Mongolia for 310,000 MNT. PV modules are from China and cost 4 USD/W_p and are sold for 5 USD/W_p. Malchin also sells a 12 W_p PV module for 85,000 MNT.

Batteries are manufactured in China, as are charge controllers (6-9 V, max 20 A). Malchin stocks a 16 W, 12 V CFL which they sell for 5,000 MNT and a 7 W, 12 V CFL sold for 2,500 MNT: both are screw fitting.

Monmar Company

Monmar used to produce wind turbines ceased production in 2000 due to lack of profitability and because of the failure rate of the turbines the subsequent need for frequent change of parts. While still producing wind turbines they used Marlec technology and components and produced 1,000 of the planned 10,000 they hoped to produce for use by herdsmen. Each wind turbine was rated at 50 W and cost 200,000 MNT.

Monmar still assembles some PV modules using components from Germany, China, UK, USA and Italy. Monmar also sells batteries from France, CFLs from Korea. The company imports 160 W_p PV modules from Italy and 50 W_p modules from BP Solar (sold in Mongolia for 300,000 MNT). Monmar manufactures a 5 W_p, 6 V PV module for powering CFL lights. This is a large part of the company's business and sells for 150,000 MNT per system (this includes the PV module and the CFL light). More recently, Monmar has started to compete in tenders for larger installations: its last large installation project was a 1,200 W_p PV system for a border customs station. Entering into tenders and the installation of solar home systems (using some PV modules of its own production) are now the main business. The company installed 12 systems 2003 with a combined total capacity for all sites of 15 kW_p.

National Renewable Energy Center (NREC)

Although NREC used to sell PV equipment, the company has recently focussed on installations work and undertaking consultancy studies. NREC is currently undertaking a study of RE resources in Mongolia with GTZ (Utilisation of RE in Rural Areas of Mongolia, 1999-2007). The company is also working with GTZ, to develop a 375 kW hydro power station in Tosontsengel Soum of Zarkhan province (2002-mid 2004). In addition to these, REC is undertaking a number of smaller projects commissioned by the Mongolian government and national institutions.

NREC is collecting data for a wind farm project planned at 500 kW per wind turbine with 60 turbines per site. This project is funded by the GoM. REC installs PV but could not elaborate on the technology or equipment used (source, qualifications) because all equipment is chosen and provided by whoever is commissioning a given project. NREC now limits itself to carrying out surveys and installations.

SOBBI Company

SOBBI Company is a Mongolian owned wind and PV production and installation company operating in Ulaanbaatar since 1993. SOBBI is Mongolia's only licensed supplier of Southwest Wind Power's wind turbine. Southwest Wind Power is an American company which ships its turbine to SOBBI for assembly (turbine only, the tower is made in Mongolia). The turbine used by SOBBI is called Air 403 and has a range of 400 W to 3 kW. Specification for the 400 W turbine which is most commonly used by SOBBI is as follows:

- 3 year warranty, sold for about 800 USD.
- rotor diameter 1.5 meters, weight 13 lbs.
- mount: 1.5 inch pipe.
- start up wind speed: 2.7 $m.s^{-1}$.
- voltage: 12 V, 24 V, 48 V DC.
- rated output: 400 W at 12.4 $m.s^{-1}$.

Inventory of RE Technologies

Renewable Energy Projects in Mongolia

Error! Reference source not found.below lists solar and wind energy projects in Mongolia, for both institutions and households (typically herders).

List of Solar and Wind Energy Systems in Mongolia

Type of systems	Quantity	Places
Solar bath-houses (Vacuum collector 60-120 l)	30	Zavkhan province
PV and wind systems for public organisations:		
PV system for hospitals (200-400 W)	12	Khovd, Govi-Altai, Arkhangai provinces
PV system for border guard squad	22	Squads in Sulinkheer, Dornogovi province
PV system for telecom office (900 W)	140	All provinces
PV system for radio-relay station (5.7 kW)	29	Central provinces
Solar wind hybrid systems (5-6 kW)	6	Tariat, Adaatsag, Bayan-Undur, Guchin-Us, Bogd, Tsagaanchuluut soum centers
PV systems (5 kW)	1	Naran soum, Sukhbaatar province
PV power plants (200 kW)	1	Noyon soum, Umnugovi province
Wind systems (25k W)	1	Bayandelger soum, Sukhbaatar province
PV and wind systems for herders:		
PV systems (4-200 W)	10000	All provinces
PV systems of JICA (62 W)	11170	
Wind generators (50-200 W)	4000	

List of Hydro Power Plants in Mongolia

Name	Capacity (kW)	Status
Munkhkhairkhan HPP, Khovd province	150	In operation
Guulin HPP, Govi-Altai province	400	In operation
HPP on Chigj River, Uvs province	200	In operation
Mankhan HPP, Khovd province	150	In operation
HPP on Bogd River, Zavkhan province	2000	In operation
Uyench HPP, Khovd province	900	Under construction
Tosontsengel HPP, Zavkhan province	375	Under construction
Ulaanboom HPP, Uvs province	11000	Under construction

Rate Capacity of Electric Home Appliances & Estimation of Demand Rate

Electric home appliances are usually not used simultaneously among end users in the soums, the demand rate is estimated taking into account the average time to be switched on continuously and rate that households use the electric appliances simultaneously. Respondents have replied in questionnaires that almost all of them use their refrigerators, however, in most soums diesel stations are operated for 4-5 hours a day and there are no possibilities to switch on refrigerators during that period. And households have almost no chance to use some electric appliances with high power such as microwave oven, cooker, iron and water heater between 19-22 p.m. They can only use low-powered appliances as TV sets, radios.

Rated Capacity and Electric Home Appliances	No.	Electric Appliances and Lights	Rated Capacity (W)	Simultaneous Use Rate
Households	1	Black & White TV	35.3	0.80
	2	Color TV	130.2	0.80
	3	Radio	28.1	0.10
	4	Recorder (CD, Video)	56.1	0.10
	5	Computer	442.8	0.10
	6	Air conditioner (Fan)	147.7	0.10
	7	Refrigerator	710.5	1.00
	8	Microwave Oven	1,566.6	0.05
	9	Electric Water Heating	1,812.5	0.05
	10	Electric Rice Cooker	555.9	0.05
	11	Electric Iron	1,129.8	0.05
	12	Washing Machine	750.6	0.10
	13	Sewing Machine	510.5	0.10
	14	Vacuum Cleaner	1,237.1	0.10
	15	Other	1,656.6	0.00
	1	Lights	100.00	0.7

	No.	Electric Appliances (Inc. Light)	Rated Capacity (W)	Simultaneous Use Rate
Public Facilities	1	Incandescent Light	100	0.3
	2	Fluorescent Light	40	0.3
	3	Black & White TV	58	0.1
	4	Color TV	147	0.1
	5	Radio	47	0.1
	6	Cassette Recorder (CD, Video)	268	0.1
	7	Air Conditioner(Fan)	33	0.1
	8	Refrigerator	1,042	1.0
	9	Microwave	1,570	0.1
	10	Electric Water Heater	2,100	0.1
	11	Electric Iron	1,806	0.1

	12	Washing Machine	899	0.1
	13	Sewing Machine	600	0.1
	14	Slide Projector	1,980	0.1
	15	Radio Comm. Equip.	1,020	0.1
	16	Personal Computer	1,093	0.1
	17	Printer	1,024	0.1
	18	Copy Machine	1,021	0.1
	19	Vacuum Machine	1,200	0.1
	20	Sterilizer	1,396	0.1
	21	X-ray Machine	1,100	1.0
	22	Steam Generator	650	1.0
	23	Centrifugal Separator	1,200	1.0
	24	Distiller	1,157	0.1
	25	Operating Light	1,214	0.1
	26	Newborn Infant Incubator	1,375	0.1
	27	Ultrasonic Medical Apparatus	400	0.1
	28	Oxygen Generator	1,350	0.1
	29	Other	2,525	0.0