

**ASIAN DEVELOPMENT BANK**

**TAR: MON 36255**

**TECHNICAL ASSISTANCE**  
(Financed by the Government of Denmark)

**TO**

**MONGOLIA**

**FOR**

**RENEWABLE ENERGY DEVELOPMENT IN**

**SMALL TOWNS AND RURAL AREAS**

**November 2002**

## **CURRENCY EQUIVALENTS**

(as of 1 October 2002)

Currency Unit	–	Togrog (NMT)
NMT 1.00	=	\$ 0.000895
\$1.00	=	NMT 1,117

## **ABBREVIATIONS**

ADB	–	Asian Development Bank
CES	–	Central Energy System
EES	–	Eastern Energy System
ERA	–	Energy Regulatory Authority
kV	–	kilovolt
MW	–	megawatt
TA	–	technical assistance
WES	–	Western Energy System

## **NOTE**

In this report, "\$" refers to US dollars.

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## I. INTRODUCTION

1. At the request of the Government of Mongolia, technical assistance (TA) to promote off-grid renewable energy, for small-towns in rural areas of Mongolia was included in the 2002 TA program of the Asian Development Bank (ADB). The TA<sup>1</sup> will assist the Government to develop a renewable energy strategy for isolated rural areas, study hybrid pilot systems that may complement existing diesel generation in schools and hospitals, and analyze options for mainstreaming renewable energy to improve access for poor nomadic families. The Fact-Finding Mission in July 2002 and subsequent communications concluded an understanding with the Government on the goals, purpose, scope, approach, cost estimates, and implementation arrangements for the TA. The TA framework is in Appendix 1.

## II. ISSUES

2. In Mongolia, the primary commercial energy resources are indigenous coal and imported petroleum products. Coal is used for generating electricity and heat; petroleum products are used mainly for transportation and electricity generation in isolated systems. The country has large coal reserves (about 50 billion metric tons). Although about one fifth of the coal is high quality, only the low quality brown coal (lignite) adjacent to the population centers is currently mined. Mongolia also has limited hydropower resources, which remain undeveloped. Hydrocarbon deposits have not been fully surveyed but are thought to hold potential. Traditional fuels such as animal dung and wood are used in many remote areas where it is difficult to supply commercial energy resources. The Mongolian thermal power generation capacity consists of seven coal-fired combined heat and power generation plants and numerous diesel power stations, mostly, off-grid province and village centers.

3. Three independent transmission grids (the Central Energy System or CES, Eastern Energy System or EES, and Western Energy System or WES) and five isolated province centers cover the vast country. The CES reaches about 53% of the population and covers 40% of the land. In 2000, the grid supply amounted to 3,130 gigawatt-hour (GWh) with a total load of 558 megawatt (MW). CES supplied more than 96%, EES about 2%, WES 0.7%, and the five isolated province centers 1.2%. The average load factors are: CES 65%, EES 61%, WES 32% and isolated province centers 36%. Both the CES and WES are connected to the Russian grid and WES relies mostly on imported energy from Russia. The electricity grid of the CES consists of a large 220 kV and 110 kilovolt (kV) transmission network. It comprises 5 substations at 220 kV and 54 at 110 kV. A 220 kV ring system interconnects the principal generation and load centers of Darkan, Erdenet, and Ulaanbaatar, and further 220 kV interconnections are going to the load centers of Baganuur and Choir. The CES 220 kV grid is connected to the Russian system by a 220 kV double circuit line. Primary distribution is mainly at 35 kV.

4. The Government initiated a rapid transformation from a centrally planned to a market-oriented economy in 1990. ADB loan<sup>2</sup> conditions required the Government to implement the restructuring action plan for the energy sector, which included enactment of the energy law. The Energy Law provides a basic regulatory, inspection, and enforcement structure for producers, suppliers, and consumers. It allows private and public sector involvement in the production of energy and establishes key policies in areas of tariff, energy efficiency, environmental quality, and safety. The Mongolian electricity industry—with total installed capacity of only 830 MW—was recently unbundled into 18 companies including 9 generation, 4 electricity distribution, 2 heat distribution, and 3 electricity transmission companies. Independent

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<sup>1</sup> The TA first appeared in *ADB Business Opportunities* (Internet edition) on 7 June 2002.

<sup>2</sup> ADB. 1994. *Report and Recommendation of the President on a Proposed Loan to Mongolia for Power Rehabilitation Project*. Manila.

regulation was also introduced as part of the deregulation initiative. A single buyer model is being implemented as a proxy for implementing a wholesale electricity market. Under the model, the transmission companies will allocate a proportion of their revenues to distribution companies under the guidance of the Energy Regulatory Authority (ERA). ERA has power, to set requirements for licenses for generation, transmission, distribution, dispatching of heat and electricity; issue and revoke licenses; develop methodology for determining tariffs; resolve disputes between licensees; and define the level of supply reliability. ERA was established with its representative offices in each of the 18 provinces. The grid covers 97% of the total electricity supply. Currently 33% of the population does not have access to electricity; 10% of those without electricity live in village centers and 82% live in remote rural area.

5. The Government has focused on improving rural living conditions to arrest the increasing migration of rural population to cities, in particular to the capital Ulaanbaatar. This creates demand on schools, hospitals, and other social infrastructure services that can not be met in the short to medium term. Many rural cities were relying on economic activities created by the almost 1 million former Soviet soldiers that were permanently posted along the border with the People's Republic of China. After the withdrawal of the soldiers, general economic activities in these remote areas have shrunk; as a result, Government funds are no longer made available for public infrastructure for health, education, and energy supply. The disparity between the reality and expectations based on past service levels are contributing to the accelerated migration toward city centers, particularly to Ulaanbaatar. Poor electricity supply is a contributor to the deterioration of these public services in rural areas.

6. Each village administrative center has administrative buildings, houses, schools, dormitories, hospitals, communication facilities, other public utilities, and some permanent private houses. Village centers provide health care, education, and other supplies for the day-to-day needs of nomadic people, making them hubs for the nomadic lifestyle. The herding population needs electricity for cooking, milk processing, sewing, and lighting for reading—functions that are mostly carried out by women and children in a family. Village schools are the only formal option for a child's education in a herders family. Herders use village centers to access basic services and necessities including trading of livestock.

7. The reliability of electricity supply varies widely across Mongolia and is worst in the poorest villages, which are not connected to the grid. Of 314 village centers, only 117 are connected to grid-based electricity supply; the remaining 197 centers operate isolated systems with small diesel generation capacity (60-100 kW) that mostly operate 3-5 hours each day. Because of rough terrain and vast distances between population centers and the volume of electricity consumption due to small population, diesel generation is the most economic source of electricity for some province centers. Diesel needs to be imported, transported, and stockpiled at high volumes and supply interruptions can cause severe power shortages. Currently, during summer months, operating hours for diesel generation are reduced to minimize the cost of expensive diesel—46% of villages provide no service, 40% have only evening service, and only 13% provide electricity for full 24 hours. Lack of critical spare parts for regular maintenance can increase the frequent interruptions of supply making diesel generation extremely unreliable. The same capacity could support more users with efficient appliances.

8. The Government cannot sustain its current approach for electricity supply to the highly dispersed Mongolian population. The urban population receives poor quality electricity while the substantial rural population has little or none. The Government subsidizes the operation of utilities at each province. United States Agency for International Development (USAID) provided aid to replace some of the old Russian generators during 1997-1999 in all off-grid provinces, but the combination of high losses and low tariffs means that the authorities do not have enough

cash to maintain the generators properly and only limited emergency maintenance is undertaken, which increases outages. Despite the Government's generous subsidies, the electricity supply in the village centers is deteriorating.

9. ADB TA<sup>3</sup> concluded that while large application of renewable sources like wind, solar, and geothermal is not economic for power generation, small-scale projects could be implemented for isolated rural areas, an alternative that required further investigation. The recommendation emphasized the possible role of renewable energy in strengthening overall rural development.

10. An ADB loan<sup>4</sup> for education highlighted key problems in electricity supply for schools and kindergartens in remote rural areas. Generation of electricity using diesel is relatively expensive and schools cannot maintain a continued supply with their limited resources. Poorly designed buildings, inadequately maintained electrical systems, and use of inefficient electrical appliances amplify this problem. Renewable energy sources—although they are considered relatively expensive for most areas connected to main electricity grid—could provide cheap electricity complementing existing diesel generation. ADB's experience with remote schools suggests that lack of capital resources is the reason for low use of alternative electricity sources, such as wind and solar despite high prevailing winds and over 300 days of annual sunlight.

11. Village hospitals provide primary health care services to the rural population that are comparable to family group practices in urban areas. Electricity is typically used for fluorescent lamps, television, radio, electric kettles and a refrigerator. Village hospitals are usually equipped with beds as they serve a vast area (some patients may need to travel 200 kilometer (km) to reach a hospital). Like schools and kindergartens, lack of a reliable supply of electricity in village hospitals undermines their operations. For example, in summer when rural areas receive full summer sun exposure everyday, some village hospitals operate under candlelight at night to save diesel fuel. The ADB healthcare project<sup>5</sup> recommended that village hospitals be downsized, as hospital beds serve social and community purposes more than healthcare and these hospitals should cater to the needs of specific communities as health centers. The downsizing of village hospitals will make them more suitable for complementary hybrid renewable generation.

12. Wind and solar hybrid systems for rural hospitals, schools, dormitories, and communication centers are currently being used in some village centers and isolated initiatives are evaluating various options. There are no support facilities for maintenance of existing solar, wind, and diesel generation and spare parts are difficult to find. Higher penetration of renewable energy sources is one way of ensuring that secondary industries will be developed for maintenance. The Government and customers need to physically assess the technology that may be suitable to Mongolia. An integrated strategy should be developed to address these technical support and capacity building issues, without which the efficiency level will further deteriorate and losses will gradually erode the industry. Information on successful implementation of renewable energy generation needs to be closely studied before the possibility of a broader scale application can be addressed.

13. In Mongolia with its vast land, sparse population, and hundreds of isolated small settlements throughout the country, an off-grid solution is the most economic option to provide electricity in rural areas and isolated small towns. The major problem of the current diesel

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<sup>3</sup> ADB. 1991. *Technical Assistance to Mongolia for Capacity Building in Energy Planning*. Manila.

<sup>4</sup> ADB. 2002. *Report and Recommendation of the President on a Proposed Loan to Mongolia for the Second Education Development Project*. Manila.

<sup>5</sup> ADB. 2001. *Technical Assistance for Mongolia for the Second Health Sector Project*. Manila.

system is the pressure of the recurrent expenditures for operation and maintenance that often cause interruptions in power supply. This is also a major concern to ensuring the success of ADB's poverty reduction intervention in the health, education, and municipal services in rural areas and small towns. Given its natural endowment, Mongolia has great potential to benefit from the appropriate technology in renewable energy. Large scale use of renewable energy will require policy support, substantive capital investment, skilled labor to operate and maintain, regular maintenance, and stable supply of spare parts. These have technical and financial implications, which may be why the country has used only limited renewable energy.

### **III. THE TECHNICAL ASSISTANCE**

#### **A. Purpose and Output**

14. The immediate purpose of the TA will be to assist the Government to undertake a comprehensive assessment—through policy study, technical review, and a few pilot schemes—of the technical feasibility and economic viability of new renewable energy technology under Mongolian circumstances, as a basis for decision making and policy formulation. The TA will assist the Government to develop a renewable energy policy for isolated rural areas and formulate strategies for implementation. The strategy will identify options for mainstreaming renewable energy to improve access to electricity for poor nomadic families.

15. The TA will (i) formulate a renewable energy policy and study existing renewable energy use in Mongolia; (ii) finance a renewable energy exhibit in Ulaanbaatar; (iii) develop a campaign for mainstreaming renewable energy in rural areas; (iv) select appropriate technology from the exhibit, if possible, and design pilot projects for wind-diesel or solar-diesel hybrid systems—two sources of power that complement each other to supply schools and hospitals in village areas; (v) implement pilot projects<sup>6</sup> and periodically monitor technical performance and reliability of hybrid systems for a year; (vi) publish results of monitoring; (vii) analyze options for possible private sector participation by way of maintenance contracts for maintaining diesel and hybrid systems for the whole region; and (viii) develop leasing options by packaging existing subsidies and other sources to develop a single tariff solution for installing hybrid systems in schools and hospitals.

#### **B. Methodology and Key Activities**

16. The TA will adopt a consultative participatory approach and build on the work of the Government and other agencies. Key activities will include policy dialogue with the Government, the workshop and exhibition, a media campaign promoting renewable energy, development of a monitoring mechanism for pilot projects, development of options for outsourcing maintenance of existing diesel generation to private companies at fixed cost, formulation of packaged solutions for hybrid systems, and a report and final presentation to government and other stakeholders.

#### **C. Cost and Financing**

17. The total cost of the TA is estimated to be \$475,000 equivalent, of which \$365,000 is the foreign exchange cost and \$110,000 equivalent is the local currency cost. The Government has requested ADB to finance \$400,000 equivalent to cover the entire foreign exchange cost and \$35,000 equivalent of the local currency cost. The TA will be financed on a grant basis by the Government of Denmark (see Appendix 2).

<sup>6</sup> Efforts will be taken to reduce the need for pilot study, if possible, to increase the budget for study and training on efficient operation of diesel generation.

The Government will finance the balance of the local currency cost through the provision of office accommodation, remuneration of counterpart staff, local transport, equipment, and secretarial support.

#### **D. Implementation Arrangements**

18. The TA will require 18 person-months of services from a consulting firm: 8 from international and 10 from domestic consultants. The consulting firm team will comprise the following international and domestic experts: renewable energy economist and Team Leader, renewable energy technical expert, domestic renewable energy economist, and domestic renewable energy technical expert. All consultants will be engaged by ADB in accordance with its *Guidelines on the Use of Consultants* and other arrangements satisfactory to ADB for the engagement of domestic consultants. All procurement under the TA will be in accordance with procedures acceptable to ADB. A simplified technical proposal will be used to recruit consultants and the quality-and cost-based selection method will be used for consultant selection. Outline terms of reference for the consultants are in Appendix 3.

19. The Department for Fuel and Energy of Ministry of Infrastructure will be the Executing Agency. It will assign a project leader and counterpart staff to work with the consultants, and will provide the consultants with adequate office accommodation in Ulaanbaatar, support secretarial staff, telephone, photocopying and office services, and some local costs. The TA will be implemented over a period of 18 months to provide a full year of monitoring for the pilot projects. It will start in February 2003 and will be completed in July 2004. The major reports required from the consultants are (i) an inception report describing detail work program (3 weeks after the start of the TA); (ii) two reports describing progress of work (after 4 and 8 months); (iii) a draft final report with all deliverables including results from pilot projects as per the terms of reference (16 months); and (iv) a final report, which is the draft final report after incorporating ADB's comments (18 months).

#### **IV. THE PRESIDENT'S DECISION**

20. The President, acting under the authority delegated by the Board, has approved ADB administering technical assistance not exceeding the equivalent of \$400,000 to the Government of Mongolia to be financed on a grant basis by the Government of Denmark for Renewable Energy Development in Small Towns and Rural Areas, and hereby reports this action to the Board.

### TECHNICAL ASSISTANCE FRAMEWORK

Design Summary	Performance Targets	Monitoring Mechanism	Assumptions and Risks
<p><b>Goals</b></p> <p>Promote economic development and poverty reduction by satisfying electricity demand for remote rural customers.</p>	<p>Improve adequacy and reliability and of power supply.</p> <p>Provide electricity to new customers.</p>	<p>Energy institutions' annual reports.</p>	<p>Government's ability to provide counterpart funding and attract foreign investments to implement renewable energy solutions for large number of customers.</p>
<p><b>Purpose</b></p> <p>Develop a strategy for mainstreaming renewable energy to improve electricity supply in rural areas.</p> <p>Study hybrid pilot projects that will complement existing diesel generation in village schools and hospitals.</p>	<p>Improve reliability of supply in rural areas and increased use of renewable energy sources.</p> <p>Supply reliability in pilot schools and hospitals increased to match reliability in winter.</p>	<p>Consultants' reports, review missions.</p>	<p>Effective donor and investor coordination.</p> <p>Availability of technology that is affordable, suitable, and sustainable in the harsh Mongolian climate</p>
<p><b>Outputs</b></p> <p>An exhibition of small-scale wind, solar, and hybrid renewable technology suitable for harsh Mongolian winter.</p> <p>Recommendation for affordable practical wind and solar hybrid solutions for schools and hospitals in the 197 isolated village centers.</p> <p>Overseas study tour to Inner Mongolia (PRC) and two other countries – Norway, Denmark, Canada – to study practical application of hybrid renewable schemes.</p>	<p>Large scale participation in exhibition.</p> <p>Well designed pilot projects that are made affordable by packaging existing subsidies with government guaranteed financing.</p> <p>Successful completion of study tour.</p>	<p>Review missions, progress reports, and periodic reports by consultants.</p>	<p>Lack of funding support and interest from equipment manufacturing for the exhibition.</p> <p>Weak counterpart support.</p> <p>Poor consultant performance.</p> <p>Ability to implement study findings to wider pollution.</p>
<p><b>Activities</b></p> <p>Workshop and exhibition</p> <p>Design of pilot project</p> <p>Monitoring of pilot project results</p> <p>Project design</p> <p>Report</p>	<p>8 person-months of international and 10 person-months of domestic consulting services.</p> <p>\$475,000 equivalent = total cost; ADB financing of \$400,000, Government contribution of \$75,000.</p> <p>Conference and exhibition for a week.</p> <p>Wind and diesel, 8 kW, \$25,000</p> <p>PV and diesel 10 kW, \$60,000</p> <p>Solar water pump options at 3,000=\$10,000</p> <p>Pilot projects (hybrid system)</p>	<p>Review missions, progress reports, and consultants' report.</p>	<p>Delay in consultant recruitment.</p> <p>Delay in obtaining relevant data and information.</p>

**COST ESTIMATES AND FINANCING PLAN**

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<b>Item</b>	<b>Foreign Exchange</b>	<b>Local Currency</b>	<b>Total Cost</b>
<b>A. Asian Development Bank Financing<sup>a</sup> (Government of Denmark)</b>			
1. Consultants			
a. Remuneration and Per Diem			
i. International Consultants	174,000	0	174,000
ii. Domestic Consultants	0	15,000	15,000
b. International and Local Travel			
i. International	20,000	0	20,000
ii. Domestic	0	1,000	1,000
c. Reports and Communications	15,000	0	15,000
2. Equipment			
a. Hardware for Pilot Projects <sup>b</sup>	95,000	0	95,000
b. Softwares	1,000		1,000
3. Training, Seminars, and Conferences			
a. Overseas Study Tour	25,000	0	25,000
b. Exhibition of proper Renewable Technology	15,000	15,000	30,000
4. Representative for Contract Negotiations	5,000	0	5,000
5. Contingencies	15,000	4,000	19,000
<b>Subtotal (A)</b>	<b>365,000</b>	<b>35,000</b>	<b>400,000</b>
<b>B. Government Financing – in kind contribution</b>			
1. Office Accommodation	0	20,000	20,000
2. Remuneration and Per Diem of Counterpart Staff	0	20,000	20,000
3. Local Travel and Transport	0	10,000	10,000
4. Secretarial Support and Office Services	0	5,000	5,000
5. Office Equipment	0	10,000	10,000
6. Others	0	10,000	10,000
<b>Subtotal (B)</b>	<b>0</b>	<b>75,000</b>	<b>75,000</b>
<b>Total</b>	<b>365,000</b>	<b>110,000</b>	<b>475,000</b>

<sup>a</sup> Financed by the Government of Denmark.<sup>b</sup> Two hybrid wind and diesel, 8 kilowatt (kW), \$25,000; two solar and diesel 10kW \$60,000; two solar water pump \$10,000.

Source: Asian Development Bank estimates.

## OUTLINE TERMS OF REFERENCE FOR CONSULTANTS

1. The team of two international consultants will coordinate the two domestic consultants. The team leader will allocate tasks to the two domestic consultants (10 person-months in total) to maximize their contribution to the technical assistance (TA) depending on their experience.

### **A. Renewable Energy Economist, Team Leader (6 person-months)**

2. The team leader will do the following:

- (i) renewable energy subsector review and policy development, for the
  - (a) review all previous renewable studies, ongoing studies, the Government energy policy, restructuring plans and plans, for renewable energy sector development (if any);
  - (b) review international experience in small-scale renewable energy generation, e. g., in Canada, People's Republic of China (Inner Mongolia), Finland, Norway, Sweden, (Inner Mongolia) and United States (Alaska);
  - (c) revise and update recommendation of previous Asian Development Bank (ADB) TA<sup>7</sup> for Mongolia and summarize renewable energy initiatives in Mongolia undertaken by other external funding agencies;
  - (d) recommend a renewable energy policy for Mongolia in light of the Energy Law and Energy Efficiency Law and suggest a strategy for immediate implementation;
  - (e) comment on the regulatory framework, licensing issues, and other government policies that may need to be changed to increase the use of renewable energy;
  - (f) analyze provisions of the energy law used in other countries to promote renewable energy;
  - (g) review the new law for energy efficiency, and identify and recommend energy efficient appliances that may be financially beneficial to the remote isolated population;
  - (h) run a workshop on the renewable energy law, and provide an example of small-scale generation technology and energy efficient appliances that are relevant for Mongolia;
  - (i) develop an energy action plan for small rural town to integrate with National Action Plan; and
  - (j) establish potential volumes of renewable energy use in remote and rural areas of Mongolia in the short and medium terms.

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<sup>7</sup> ADB. 1999. *TA to Mongolia for Capacity Building in Energy Planning*. Manila.

- (ii) for access for the poor and private sector participation, develop
  - (a) innovative options for making renewable energy more affordable for the nomadic population and for schools and hospitals; and
  - (b) options for promoting entrepreneurial initiatives for maintaining diesel plants, including options for long-term contracts, and lease and maintenance contracts with private individuals and contractors;
- (iii) for financing options
  - (a) develop least cost financing options for village hospitals and schools for the hybrid systems;
  - (b) analyze the financial feasibility, including tariff and leasing options (highlighting examples), that may be used to make renewable energy attractive to the poor nomadic population; and
  - (c) design a project for large-scale implementation of 400-600 kilowatt (kW) systems to a wider rural population, taking into account optimum use of existing government subsidy and possible packaging with inexpensive external finance under government guarantee.
- (iv) for project management and reporting,
  - (a) be responsible for coordinating work of renewable international energy technical expert and the local consultants;
  - (b) prepare an inception report describing detail work program (3 weeks); a - term report describing progress of work (4 months); a report describing progress of work (8 months); a draft final report with all deliverables including results from pilot projects as per the terms of reference (16 months); and a final report, which is the draft final report after incorporating ADB's comments (18 months);
  - (c) present recommendations at a workshop.

## **B. Renewable Energy Technical Expert (2 person-months)**

3. The expert will do the following:

- (i) for pilot project implementation and design,
  - (a) visit village areas and prepare an inventory of existing renewable energy technologies that are currently in use and potential new technologies that can be used as a hybrid with existing diesel generation in school and hospitals in villages;
  - (b) perform an energy audit of appliances in village hospitals, schools, and isolated remote residences and develop list of energy efficient appliances that can be used in them to achieve immediate energy savings;

- (c) recommend options for improving diesel generation and identify constraints, if any, for installing complementary wind or solar with existing generation;
  - (d) develop three designs for pilot testing wind-diesel and solar-diesel hybrid systems with complete specifications that will be able to co-exist with existing diesel generation, including options for solar water pumps (if possible);
  - (e) analyze information available on hybrid systems that may be suitable for Mongolian condition to reduce the requirement for pilot testing;
  - (f) select sites for pilot projects after full consultation with government and other local stakeholders; and
  - (g) supervise implementation of pilot projects and develop mechanisms for weekly monitoring and reporting.
- (ii) renewable energy exhibition and capacity building
- (a) finalize a list of hybrid technologies suitable for hospitals and schools in off-grid village centers;
  - (b) design an action plan for a renewable energy exhibition in consultation with the government and other stakeholders, and design a media campaign plan to educate the wider population on renewable technology;
  - (c) assist the Government in organizing the exhibition, including preparation of list of likely exhibitors to be invited;
  - (d) develop criteria for selecting pilot hybrid equipment in consultation with the Government and ADB; and
  - (e) design and organize overseas training for the key policy makers and other stakeholders.

### **C. Domestic Consultants (10 person-months)**

4. Domestic consultants will be recruited to assist the international consulting team. These consultants should have extensive in-depth local industry knowledge and good contacts in the energy industry. Domestic consultants will assist international consultants to quickly become familiarized with their tasks by translating various documents into English; researching and compiling a set of government policies, regulations, and procedures adopted; and ensuring the work by international consultants is appropriate to the Mongolian situation. Domestic consultants are expected to possess sufficient experience in their relevant fields, and will include a renewable energy economist and renewable energy technical expert.