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STRENGTHENING THE TECHNOLOGICAL BASE OF MPR STATE COMMITTEE FOR SCIENCE AND TECHNOLOGY FOR DESIGNING PRODUCTION AND TESTING OF PROTOTYPES BASED ON SCIENTIFIC RESEARCH

ST/MON/82/001

MONGOLIA

Technical report: Wind and solar energy resources

Prepared for the Government of the Mongolian People's Republic by the United Nations Industrial Development Organization, acting as executing agency for the United Nations Development Programme

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Explanatory notes

In addition to the common abbreviations, symbols and terms, the following have been used in this report.

MWE	Ministry of Water Economy
MAE	Ministry of Agricultural Economy
MFEI	Ministry of Fuel and Electric Industry
IPT	Institute of Physics and Technology
SCST	State Committee for Science and Technology

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INTRODUCTION

Mongolia is a mountainous country with an area of 1,566,500 km^2 and a population of 1,685,400. There are four natural climatic zones: forest steppe, steppe, mountain and the Gobi desert.

The structure of the gross output of the economy, in percentage terms, is as follows: industry, 40; agriculture, 20; construction, 10; and transport and communications, 10. Material supply, trade and State purchases make up the rest of the output. The distribution of the work-force in the main sectors of the economy is as follows: industry and construction, 21.5 per cent; agriculture and forestry, 40.4 per cent. The remainder is spread amongst other fields of the economy. This high proportion of the work-force occupied in agriculture demonstrates the large amount of manual labour that is usually required in that sector. Mechanical means, such as small machines and fuel-driven equipment, are scarce. However, the history of energy development is connected with the history of human development and much attention is being paid to the energy problem of the developing countries at the international level. This is plain from the decisions of the United Nations Conference on Renewable Energy Sources held at Nairobi in August 1981.

A number of institutes of the Scientific Academy of Mongolia's Institute of Physics and Technology (IPT) - the Ministry of Water Economy (MWE), the Ministry of Agricultural Economy (MAE) and the Ministry of Fuel and Electric Industry (MFEI) - have begun to carry out scientific investigations into designing different mechanical means for all branches of the economy. Engineering for the agricultural sector is the most pressing need. Much scientific and design work is therefore being done on the use of wind and solar energy in agriculture. Mongolia's climatic conditions are more favourable for using these types of energy than those of other developing countries. However, there is no well-equipped technological base for the necessary energy-related engineering. Moreover, there are no well-equipped institutes or proving grounds for the preparation of the necessary technical documentation or the testing of experimental prototypes.

In this report, an attempt is made to summarize the experience gained through work carried out previously, using inputs from the Government and the United Nations, and to present some preliminary recommendations.

RECOMMENDATIONS

1. To organize the training of Mongolian fellows abroad, according to programmes elaborated to this end.

2. To supply, as soon as possible, equipment for the partial production of solar cells and for improving the testing of wind power stations and solar heating systems.

3. To work out a programme and method of recording the ever-changing characteristics of solar power and wind energy, in order to design appropriate control systems.

4. To find a possibility for the State Committee for Science and Technology (SCST) to establish an experimental design unit for designing complete technical documentation for solar heating systems, solar cells and wind power stations and, at the same time, to solve the organizational problem of disseminating, to industry, the technical documentation emanating from experimental, pilot and manufacturing operations.

5. To find a way of financing both the project and the construction of a technological base for producing experimental prototypes based on research work.

6. To organize high-level and professional training of national personnel for agricultural energy services.

7. To find a way of organizing an agricultural energy service for installing and maintaining energy and electrical equipment.

8. To find a way of establishing a subdivision for testing experimental prototypes on a technological basis.

I. BACKGROUND

A. Traditional energy sources

Coal. Coal is a main energy source for Mongolia's industry. It is used for the central State power system, which supplies electricity for plants, factories, the coal and other mining industries, and major agricultural consumers (poultry, cattle and pig farms, greenhouses). It is also a fundamental source of heating for dwellings in most towns, villages and rural regions. Annual coal output is about 4,376 million tons. Electricity power stations consume 42 per cent of this output and agriculture 5.2 per cent. The capacity of the electric power stations is 430,000 kW, the annual production of electricity being 1,634.7 million kWh. The cost of electricity for dwelling needs is 0.35 tughriks per kWh. The central electricity power system covers 12 per cent of the country, where 35 per cent of the population are concentrated. There are some domestic heat power stations in Choibalsan (24 MW), in Bayan-Ulgii aimak (9 MW) and in Dzabkhan aimak (2 MW). Rural consumers, which have a density load of 1-1.5 kW per km^2, account for 70 per cent of total electricity output. The density of the electric load is 0.03-0.2 kW per km^2. It is thus necessary to develop the supply of electricity by maximizing the use of domestic energy resources.

Oil. Some 94 per cent of the agricultural sector is provided with electricity from diesel powered stations with capacities of 26,000 kW (800 units). The annual electricity output is 31.2 million kWh, at a cost of 0.6-1.5 tughriks per kWh for diesel powered stations and 1.3-2.5 tughriks per kWh for petroleum powered stations. About 50,000 tons of fuel must be imported for these purposes, because Mongolia's own oil reserves have no industrial significance.

Wood and manure. Wood and manure are used for cooking and heating. The annual consumption of manure is more than 300,000 tons.

Analyses of reserves of traditional energy sources show that it is necessary to design small systems that work off these reserves to supply the energy needed to heat dwellings, breeding farms and water, and to complement these systems with solar systems and water pumping stations.

B. Climate and actinometry

1. Air temperature

Mongolia's climate can boast 250 sunny (and 9-23 cloudy) days in a year. The period in which temperatures are above 0 °C lasts about 170-190 days, increasing in the south and south-east to 200-215 days. Highest temperatures are recorded in July, varying from 12 to 20 °C, and up to 25 °C in the south. The lowest temperatures reach -15 °C in January in the middle region and -25 °C in the north. The temperature can fall to -50 °C, however. The number of hours when the air temperature is -20 °C is 500-1,500 in the south and south-east, but 1,500-2,500 in the north. Temperatures of -30 °C are reached for 50-100 hours a year in the south and for 1,000-2,000 hours in the north. The heating season lasts for 210-260 days every year, depending on the region. The absolute minimum ground temperature reaches -52--54 °C and the absolute maximum reaches 67-69 °C. There is permafrost in some regions of the country. The maximum permafrost (1-1.2 m) occurs in February-March and the minimum in September-October. The relative air humidity varies from 55 to 65 per cent during the year. The amount of precipitation varies with the season. Some 8-10 per cent occurs during the cold seasons, and 65-78 per cent during two to three months of the summer. The lowest amount of precipitation occurs in January and the highest in July. Annual precipitation is 100-300 mm.

2. Solar energy

There are 2,700-3,300 hours of sun annually (more than in France, a leading country in the use of solar energy). There are never more than two cloudy days in succession, something rarely observed elsewhere on the planet. These conditions are caused by Mongolia's altitude above sea level; the country receives a high level of both direct and indirect solar radiation. Annual solar radiation for the whole of Mongolia is 8.3×10^{15} MJ or 2.3×10^{15} kWh. This energy is a trillion times more than the electricity generated by all of Mongolia's electric power stations and 230 times more than the electricity output of all the electric power stations in the world. This abundance of stable, ecologically clean, solar energy in Mongolia has practical possibilities of being transformed also into other types of energy.

3. Wind energy

Any evaluation of the potential of wind energy must take into consideration the peculiarities of wind speed and the variations in air flow, ranging from full calm to storm conditions. About 450,000 km^2 (28.7 per cent) of Mongolia has an annual wind speed of 4 m/s and above; 100,000-380,000 km^2 (24.4 per cent) has a speed of 3-4 m/s. The recurrence of different wind speeds is a general characteristic of wind energy measurement at various wind power stations. Observation of this recurrence over many years is shown in figure I. The approximate number of operational hours is shown in table 1. The required wind speed is evaluated in figure II. The annual wind energy potential of the country is 836.8 million kW, using 4,500-5,000 hours per year. An output of 1,129.7 million kWh of electricity can be achieved using a wind energy coefficient of 30 per cent. It is possible to get 90.4-112.9 milliard kWh using 8-10 per cent of the potential wind energy resources. The possibility of wind energy measurement predetermines the design of wind power stations for electricity output. Such stations could provide a vital input to Mongolia's economy.

Table 1. Annual possible working hours of wind power stations in the desert and semi-desert zones of Mongolia

Meteorological zone	Annual wind speed, V (m/s)	Annual possible working hours by speed			
		3.6	3.5	4.0	4.5
Mandalgobi	5.41	6 333	5 933	5 334	4 878
Dalanzadgad	4.19	5 579	4 983	4 388	3 880
Sauntand	5.05	6 132	5 597	5 063	4 590
Annual total	4.9	6 014	5 137	4 928	4 456

Figure I. Distribution of speed and duration of wind

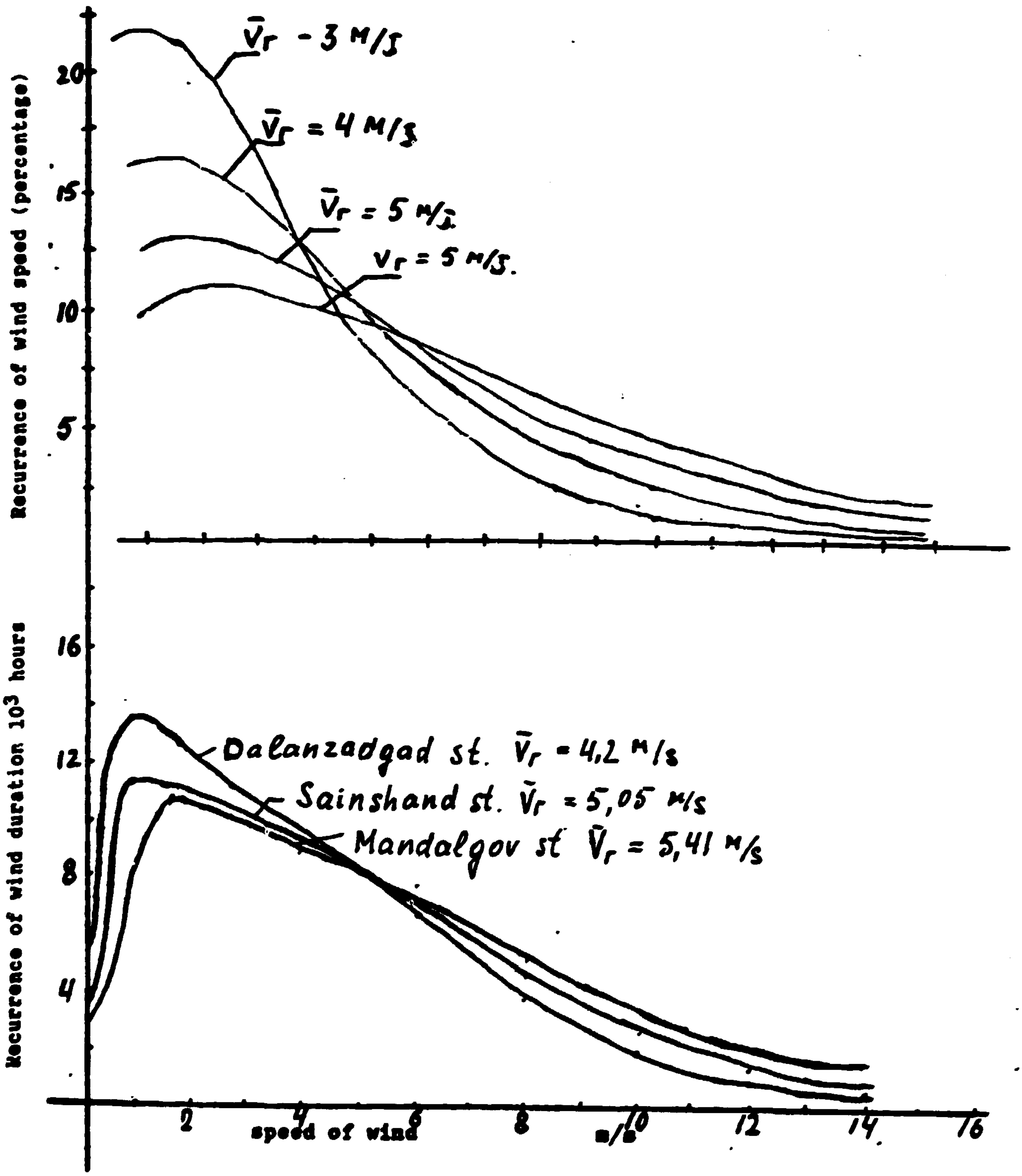
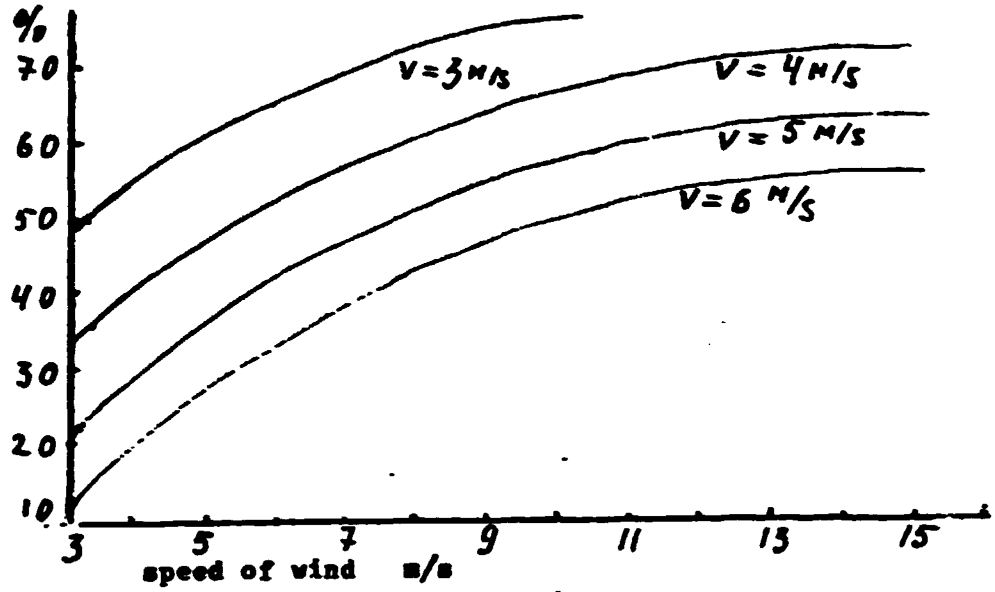


Figure II. Wind speed of wind stations, including speed at the station for desert and semi-desert zones of Mongolia



4. Water resources

Water for pastures, animals and home needs is provided from different types of wells (table 2). It is possible to use water from rivers only in summer, because all rivers are frozen in winter.

Table 2. Distribution of wells etc. in Mongolia

Type	Number	Percentage of total
Springs	2 100	5.4
Pit wells	13 805	35.8
Draw wells	10 615	27.4
Bore wells	8 700	22.5
Ponds	1 195	3.1
Hydraulic reservoirs	1 930	5.0
Total	38 665	100.0

There are 34,400 agricultural suuries (small units consisting of one or two families that live in yurts) in the country, where 140,000 of the population work. Every suury keeps 500-1,000 sheep and goats or 150-200 cows, horses and camels.

There are more than 20,000 wells that could use wind power. The output of most is 0.5 l/s. It is particularly necessary to take into account the combination of both the productivity of pumping equipment and the output of the wells. Mechanized pumping of water from wells is seen only irregularly in the country. Manual labour accounts for 70 per cent in the Gobi zone, 80 per cent in the forest steppe zone and 56 per cent in the steppe zone. Most wells are frozen in the cold season and are thus not suitable for providing water for people or animals. As sheep annually lose 3-4 kg in weight and 1-1.2 kg in wool because of the lack of water, it would be possible to increase annual output by 18,000-20,000 tons of meat and 6,000-7,000 tons of wool by good watering. From the above, it is clear that it is necessary to design water pumping stations with capacities of 0.5 l/s and wind power stations to provide electricity for home needs.

C. Technical means of transforming wind and solar energy

Worldwide, there is a great deal of experience in using wind and solar energy. Different arrangements and equipment were demonstrated in Mongolia under project MON/75/006:

(a) Mobile electrical units for supplying yurts with minimal power requirements;

(b) Stationary systems for providing electricity for home and some technological needs;

(c) Instruments for measuring solar radiation and photovoltaic testing equipment (23 types of photovoltaic equipment were provided at a cost of $US 150,580);

(d) Mobile and stationary wind power stations with a charging arrangement, which were made in Finland, France, Switzerland, the United Kingdom of Great Britain and Northern Ireland and the Union of Soviet Socialist Republics;

(e) Active and passive solar systems for heating dwellings.

As a result of the demonstration, some recommendations were worked out for using solar and wind energy for technological and home needs. In addition, suggestions were made for the design and building of solar-heated houses.

The next logical step in the development of Mongolia's national techniques is the design of equipment and systems that correspond to specific domestic requirements. First, however, it is necessary to have a technological basis (involving both scientific and design work) for producing experimental prototypes and to introduce new concepts.

Some institutes are already considering such questions. They have different types of repair shops and limited quantities of machine tools and personnel. There are also some design groups, consisting of five or six people, who design projects and prepare documentation for experimental prototypes. Equipment and raw material needs are met according to the budget of the institute, as a rule.

In this connection, activities under project ST/MON/82/001 include the following:

(a) To assist the SCST to strengthen its technological base related to the design and subsequent analysis of prototype mechanical and electronic equipment based on research work being carried out in Mongolia;

(b) To assist the SCST to establish information systems to link all activities related to the design of prototypes with the Centre for Scientific and Technological Information;

(c) To assist in training local engineering personnel in the design of prototype mechanical and electronic equipment using wind and solar energy;

(d) To prepare a comprehensive programme to strengthen national capabilities with regard to the design of prototype mechanical and electronic equipment.

II. ACTIVITIES AND RESULTS

The activities of the project were carried out in accordance with the work plan (from 1 July 1983 to 25 April 1984) as well as the work programme for the same period. The following results were achieved.

A. Solar cells

The technology of producing solar cells was worked out by the Institute of Physics and Technology (IPT) of the Scientific Academy for unit capacities of 0.2-0.5 W, which is used to feed radioset "VEF" Sokol. The efficiency of the solar cells is 6-7 per cent on ground monocrystal silicon and 3-4 per cent on ground band silicon. Solar cells are produced on antiquated equipment at the II laboratory of IPT. Thirty solar cells have been produced to date which are being tested in South Gobi and other aimags of Mongolia. Preliminary tests are being carried out at the laboratory under "ORIEL", which imitates the sun, in the ground programme, and using methods that were worked out with the help of the United Nations, taking into account the experience of the Solar Energy Institute in the United States of America, the European Centre for Solar Energy Investigation, and methods developed by the Council for Mutual Economic Assistance. An investigation has been carried out to design technology for producing solar cells with efficiencies of 11-12 per cent and also to design technology for making a contact between a conductor and solar cells. The purpose is to implement the plan to provide electricity for suurys using solar cells, the production of which provides the necessary technological base.

The first logical step was to work out the technico-economic basis for a factory to produce a solar battery of 125,000 units with a capacity of 6 W each. The annual capacity is 150 kW. The expenditure for building such a factory is about 800,000 tughriks, and $834,000 for equipment. The annual cost of production will be about 5 million tughriks. Technical and economic calculations show that the cost of solar cells will be 481 tughriks per unit (36 elements) on this basis and the cost of 1 W of power will be 80 tughriks. The cost of one module with transformer and the charging regulator of the accumulator will be from 777 to 3,716 tughriks depending on unit capacity. The falling prices of raw materials, and improvements in technology, will allow for reductions in the cost of solar cells, as shown in table 3. Project "EDPA", in the United States, expects to reduce the cost of solar cells in three steps between 1976 and 2000 (table 3). The technology of producing solar energy costs half that in European countries.

The economic effectiveness of solar cells of type SB-250 is 30.54 tughriks in a year, which was determined for Mongolian conditions in order to demonstrate the indexes. There are no other alternative mobile sources with capacities of 10 W to compete with photovoltaic cells, taking into consideration cost, reliability etc. The requirements of suuries, khesegs and agricultural societies are evaluated at 47 MW of solar cell capacity. The total agriculture requirement is about 50 MW of solar cells. The development of the above in this direction will help solve one of the problems affecting Mongolia's economy and will help improve the social condition of arats.

B. Solar heating equipment

The IPT (Scientific Academy) has gained much experience in the design of solar heating systems. Some 10 m^2 of water solar collectors were produced in one air collector. The heat accumulator consisted of several materials. In addition, a solar system working on a two-counter net was installed (figure III). This system has a dubbing stove, which maintains the level of the output water temperature when the outside temperature is very low as well

Table 3. Indexes for the production of solar cells according to project "EPDA" from 1976 to 2000

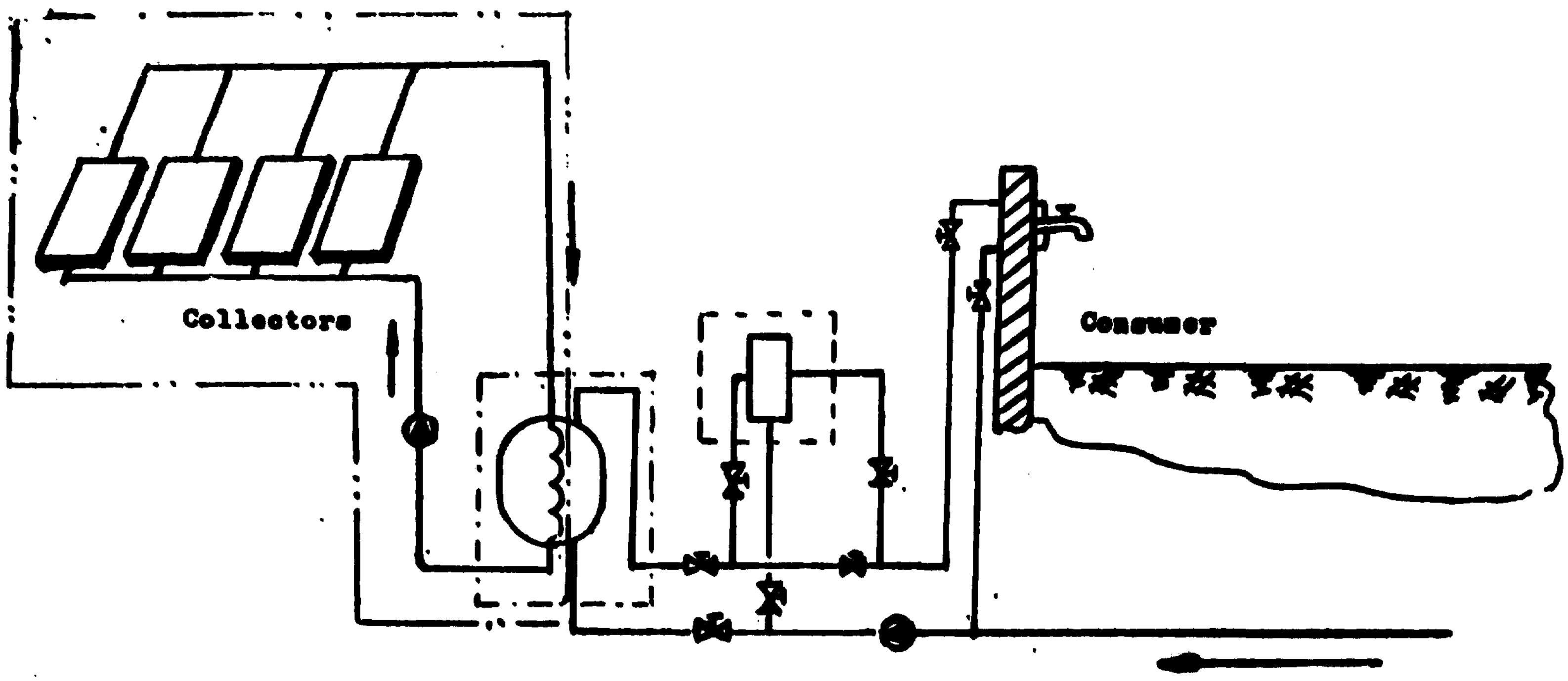
Stage	First, 1976-1985	Second, 1986-1995	Third, 1996-2000
Purpose		Transition to large-scale production	Absolute production
Technology of production	Improvement of technology, partial automation, manufacture	Introduction of new technology, complete automation, manufacture, corporation of processes	Improvement of technological methods
Efficiency of cells (AMI, %)	12	14	16
(s/m^2)	2 000	100-160	21-100
Cost of cells at beginning ($/W)	20	0.8-5	<0.8
($\$/m^2$)	100-600	21-100	
at the end ($/W)	0.8-5	0.15-0.7	0.1-0.3
Total production			
square km power	3	460	500
power	300	50 000	80 000 annually
Cost (millions of dollars)	0.5-1.5	15 100	8-25

as using solar radiation. An accumulator smoothes the daily fluctuation of the outside air temperature. The cost of producing a 1 m^2 panel in the factory is 640 tughriks, including raw materials. The cost of the panels is spread over six to nine years. Annual economical effectiveness of solar heating panels is 5-8 tughriks per 1 m^2. Specific capital input for fresh water is 146.7 tughriks per 1 m^3 and the cost of 1 m^3 of fresh water is 4.5-13 tughriks. These data were obtained from tests on units in three zones of the country (south, middle, north) and on the proving ground of the institute. The results of the test are shown in the testing protocol. Analysis of energy consumption by rural consumers shows that 70-80 per cent is accounted for by heating needs (water, dwellings, cooking etc.). To provide this, the country would require 500,000 m^2 of collectors. However, a large capital input is not necessary to produce collectors; production can be organized at any plant that has a tinware shop. Installing and adjusting could be carried out by special establishments.

C. Wind power stations

The Institute of Husbandry and the factory of [illegible] have accumulated enough experience to investigate and test wind power stations, which are usually used to pump water for the output of electricity. Technical requirements for wind

Figure III. Solar heating system



-.-.-.- Accumulator

\- - - - Dibbing arrangement

-..-..- a part of the second contour

power stations were elaborated by representatives of institutes such as prototypes of the USSR station "CHAIKA" and the Finland station "[illegible]". These prototypes were produced in mechanical workshops. Preliminary testing of the wind power station gave good results. More than four stations will be produced and installed for testing in the regions characterized by different wind and water resources.

The poor scientific, technical and testing base, and the absence of high-level national staff will, however, create difficulties in developing this work in Mongolia in the future. In this connection, a programme to develop wind power applications for solving energy-related problems was elaborated. This was because the wind station reduces the drinking time of herds of sheep, camels and cattle by 1.5-2.0 hours, the productivity of labour increases 2.9-9.7-fold and the savings in labour expenditures is 200-700 man-hours per year, in comparison with traditional methods. Furthermore, using 1 per cent wind energy reduces the amount of fuel required by the country by 100,000 tons.

The programme foresees the strengthening (and specialization) of an existing factory through an additional input of 0.5 million tughriks. The total production volume of such a factory will be worth about 1 million tughriks, or, in terms of production of wind stations, 1,000-1,500 units per year. The cost of a wind station will be 800-13,000 tughriks. The process becomes economically effective at 400,000 tughriks per year. The time required to justify purchase of a wind station is 4.7 years. The total number of wind power stations required is 10,000 per year.

D. Establishing a technological base

In connection with the above, the next logical step is to create a technological base at SCST. The technical and economic basis for the project is currently being worked out by GIPRONII AN USSR. Total government input will be 35 million tughriks. If the United Nations finances the delivery of technological and other equipment for building the technological base, there will be a real possibility to raise living standards, especially those of the rural population.

E. Technical documentation for experimental prototypes

The technical documentation for experimental prototypes of solar cells, solar heating equipment and water pumping and wind power stations is generally prepared by the scientific staff involved in research on the prototypes. However, the scientific staff cannot produce the full volume of technical documentation necessary for production under factory conditions and for testing, given all the various characteristics of the prototypes. At present, technical requirements have been worked out for water pumping and wind power stations and for solar heating equipment, and technical documentation is available for wind power stations and solar heating equipment. Project documentation has also been prepared for solar houses and greenhouses. At the same time, it should be noted that many technical terms, including those used in plans for producing non-standard equipment, as well as project documentation for wind power stations and patent formulas, have not yet been worked out. Moreover, technical documentation designed by less than firmly-established organizations cannot be taken into consideration in making financial decisions regarding the project. In this connection, it is necessary to create experimental design bureaux at the technological base in order to accelerate institute output and to suggest rationalizations. These bureaux must have the right to issue technical documentation for experimental prototypes and to design technical projects that will relate the equipment produced to domestic conditions. This would accelerate the introduction of experimental units into the country's economy and also the production of technical documentation for specific projects.

F. Status of the technological base for testing experimental prototypes

The IPT (Scientific Academy) has a testing area on its territory for laboratory investigations, where experimental prototypes of solar heating systems with fresh water accumulators are currently being tested. Testing of solar cells is being done in East Gobi's aimak, Khankhongor somon of the South Gobi aimak under field conditions. The Institute of Husbandry has two testing areas in Ulan Bator, where a wind power station is currently being tested. The testing of the station produced by the [illegible] is being carried out at the proving ground in Bayandelger somon of Central aimak, under field conditions. The proving ground is intended most of all for research investigations and is equipped with stationary control apparatus for measuring general characteristics and natural climatic conditions. There is some apparatus, imported from other countries, for measuring wind speed, temperature and air humidity. A printout system records volume of current, tension etc. However, there is not enough measuring or control equipment to get a complete picture of the working of experimental units according to technical requirements. Proper testing methods require that prototypes be tested under field conditions, when the prototypes have a full load from the technological subject.

The programme for the technological base anticipates the establishment of three wind proving grounds: in Ulan Bator, Khankhongor somon of South Gobi aimak and Darkhan somon of Khentii aimak. The cost of the proving grounds will be 1.5 million tughriks for construction and 0.8 million for equipment. It is also envisioned building a heliocomplex such as a scientific and producing centre for testing heating systems using solar energy. The expected input is 10.88 million tughriks, including 7.66 million for equipment and 3.32 million for building. It is necessary to determine what form of organization this centre will have in terms of installation and the adjusting and mastering of prototypes. It will also be necessary to supply appropriate staff.

On this basis, solutions can be found for using a combination of wind, solar energy, water and electricity. Recommendations can also be made for a rationally introduced, non-conventional system into Mongolia's economy.

G. Ordering equipment

The requisition forms for equipment supply were sent to the UNIDO, Purchase and Contract Service in June 1983 and February 1984.

A complete set of equipment was ordered for measuring and analysing wind energy resources as follows: wind logger; anemometer with magnetic reed switch; charging station for accumulators; "easy-erect" anemometer tower; metal lockable vandal-resistant box; hand and stationary anemometers; and a wind meter. The total cost of the order was $US 34,311. The equipment was necessary to carry out investigations of wind energy and to test the working of wind power stations. In a second order, the following were ordered: oscilloscope; optic and lighting equipment for testing solar cells; quartz pipes; laminar flow benches; and diffusion gas control systems. The total cost of the equipment was $US 26,319. This equipment was used to carry out some operations in the production and testing of solar cells. Measuring equipment was ordered to provide the basis for the Institute to test experimental prototypes.

In March 1984, project management software was received for the project. At the same time a notification was received that the anemometric tower had been shipped.

H. Literature used

During the implementation of the project, the following literature was used: UNIDO technical report on the use of solar energy in Afghanistan; United States project document for solar cells; and a report on the use of solar energy and the development of solar and wind energy prototypes in Egypt, which was received in April 1984.

III. ACHIEVEMENT OF IMMEDIATE OBJECTIVES

As a result of the activities of the project, the following immediate objectives have been achieved or are realizable.

A. Establishment of new methods of designing and testing prototypes

1. New methods of designing solar cells with efficiencies of 10-11 per cent will be realized after some of the technological equipment required to fulfil certain operations in the production of solar cells has been purchased. New methods of concentration give an opportunity to get electric power that costs $US 10 per watt. For increasing the effectiveness of big power systems, a new method exists using lenses from Frenelja, Czechoslovakia, or the oriental system, "Sofia", from France. Systems with concentrators will be more than 3-6 times as effective as present systems. The testing methods foresee a new position because of the introduction of new systems of photovoltaic transformers.

2. Solar heating systems are evaluated through a new approach to the investigation of solar energy sources (solar collectors). The participation of consumers of heating energy is enlisted to determine transitional patterns in heating sources as well as for the purpose of designing control systems. New methods of producing solar collectors will be realized with the help of a new technological industry. One of the new methods of designing heating systems is a rational combination of this system with other traditional or non-traditional energy sources and the wide introduction of heating accumulation systems.

3. An innovation in designing and testing wind power stations was the mastering of methods to carry out theoretical and experimental investigations of the ever-changing patterns of wind power. Due to these ever-changing patterns, systems must be designed for controlling the rotation speed of the wind rotor.

B. Training national personnel to carry out analyses of energy resources and design prototypes

1. Training national personnel to carry out analyses of energy resources will be undertaken on the basis of the experience acquired abroad. The main requirements for an analysis of energy resources, as foreseen in the training programmes, include the following:

(a) Experience in designing wind and solar energy devices in specific parts of the country;

(b) Selection and evaluation of the range of equipment used;

(c) First-hand acquaintance with methods of investigating and testing energy harnessing devices;

(d) Study of economic effectiveness of various means of applying energy resources.

2. Means of feeding the design and test results of prototypes into computer systems will be determined after the mission of the industrial information expert.

3. A general system for introducing new output into production will be worked out at the end of the project. At present, analyses of the Institute's existing output are being carried out in readiness for preparation of the technological base required to realize the new outputs. An analysis of the technical documentation requirements for experimental prototypes is also currently being carried out, as well as an analysis of the principles for organizing introductions of the new output throughout the country.

IV. UTILIZATION OF PROJECT RESULTS

1. The elaboration of training programmes for nationals is the key to gaining experience in designing, producing and testing national prototypes of experimental wind power stations, solar cells and solar heating systems. Moreover, the organizing principles of the training programmes will be useful in designing the first experimental units and then in preparing the technical documentation.

2. Recommendations for evaluating transitional processes during the investigation of solar heating systems and wind power stations are being elaborated by experts from IPT and the Institute of Husbandry. At the same time, training programmes in equipment design are being undertaken together with training programmes in microprocessor techniques.

3. The project has served as a basis for organizing the production and testing of experimental solar heating systems, solar cells and wind power stations.

4. The analysis of the status of the technological base helped determine the second phase of the project, which was to continue the activities described above and to organize the more expeditious introduction of scientific outputs into the economy.

V. FINDINGS

1. The amount of natural resources is not sufficient to satisfy domestic needs for energy.

2. Analysis of wind and solar energy resources shows that there are rich reserves of non-traditional energy resources in Mongolia. Levels of solar radiation are high, but sharp fluctuations in temperature and wind velocity, and the presence of permafrost create difficulties in the rational usage of energy resources in the economy.

3. Analysis of possibilities for using non-traditional sources shows that there are some cases where it would be advantageous to use means of transforming solar and wind energy for pumping water, heating and electricity. Attempts are also being made to prepare technical documentation for national prototypes and to produce experimental solar cells, solar heating systems and wind power stations.

4. Analysis of the technological base showed that the factory for producing experimental wind power stations, solar cells and solar heating systems had limited possibilities for producing equipment through lack of technological equipment, raw materials and manpower.

5. Preliminary testing results from experimental prototypes showed that they could work. The shortcomings of wind power and solar heating systems were also taken into consideration.