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REPORT OF THE EXECUTIVE SECRETARY
ON THE ACTIVITIES OF THE COMMISSION

PROGRESS MADE IN THE IMPLEMENTATION OF THE
PROGRAMME OF WORK FOR THE BIENNIUM 1992-1993

Report on the

promotion of selected renewable energy projects

94-0011

INTRODUCTION

1. In many rural and remote areas of the Economic and Social Commission for Western Asia (ESCWA) region, small diesel generators are used to provide electrical and/or mechanical energy for various domestic and other purposes. Others depend on even more primitive methods -- usually involving great physical effort -- to meet their basic energy needs (lifting water from deep wells is one example). Raising the living standard of these communities requires first and foremost the provision of an adequate energy supply.

2. Based on the results of intensive research undertaken over almost a decade, the ESCWA secretariat firmly believes that solar and wind energy technologies offer a means of providing the basic energy needed to improve living conditions in scattered rural and remote communities -- particularly those that are more isolated.

3. Against this background the ESCWA secretariat has finalized a regional programme for promoting the development of renewable energy resources in several member States, in implementation of resolution 168(XV) on "Suitable projects for regional and subregional cooperation in the ESCWA region on new and renewable sources of energy", and in response to the recommendations of technical meetings -- particularly those held during the past two bienniums. The regional programme is basically designed to provide assistance to a number of ESCWA member countries in the assessment of resources in the introduction and utilization of renewable technologies, and in the execution of pilot projects. It covers such areas as solar and wind energy for water pumping and water desalination, renewable energy systems for ice-making in remote fishing communities and for food and medicine preservation, renewable energy complexes for the settlement of herders and other nomadic communities, solar agro-industrial demonstration farms, and small-scale hydro power stations.

4. Following extensive consultations with the authorities concerned in several countries of the region and discussions with experts, three projects were selected for implementation in two ESCWA member countries. The first pilot project consists of one or more solar and wind energy systems for water pumping in selected rural areas in the Syrian Arab Republic. The second project entails setting up solar/wind energy systems for the desalination of brackish/sea water in a number of possible areas in Jordan. The third project involves the establishment of solar-energy-based herder settlements in Jordan, with proper consideration given to the relevant economic and social aspects.

5. The formulation of the projects was based on a detailed technical study carried out in cooperation with the Royal Scientific Society (RSS) of Jordan. This study and the other related activities undertaken by the staff of the ESCWA Natural Resources Division involved in-depth investigations to determine the selection of suitable sites (taking into consideration the availability of solar and/or wind energy potential and the energy needs of the communities under consideration); the appropriate technologies to be utilized; and the facilities required for the installation of the envisaged renewable energy systems.

6. The following chapters examine the technical and economic aspects of the three projects, and include cost estimates for their implementation.

I. SOLAR AND WIND ENERGY FOR WATER PUMPING IN SELECTED RURAL AND REMOTE AREAS IN THE SYRIAN ARAB REPUBLIC

7. There is a large number of wells distributed all over the Syrian Arab Republic. However, traditional pumping methods are inadequate, it is difficult to supply fuel to systems in remote areas, and technical capabilities for proper operation and maintenance are sadly lacking. Wind and solar energy systems represent an efficient means of overcoming many of these problems.

8. The preparation of this part of the report involved a review and analysis of the geographical, demographic, meteorological and agricultural characteristics of the Syrian Arab Republic as a prerequisite for determining suitable sites for solar and wind energy projects, their economic feasibility, and the prospects for undertaking similar projects in other areas of the country.

9. An evaluation of these characteristics and a study of the energy situation in the Syrian Arab Republic both confirm the technical and economic feasibility of numerous solar and wind energy projects; greater potential also exists for the use of small-scale solar and wind energy systems.

10. The information and data collected and analysed by both the ESCWA secretariat and the RSS indicate that the annual average for global solar radiation in the Syrian Arab Republic ranges between 4,485 and 5,263 watt-hours per square metre per day (Wh/m^2/day). This range is relatively high, and the difference between the lower and higher values of solar radiation are small (not more than 16 per cent) -- meaning that any site in the Syrian Arab Republic can be chosen for photovoltaic (PV) applications utilization.

11. Syrian data on average annual surface wind speeds indicate that the middle, southern and eastern deserts of the country have medium wind speeds suitable for wind-powered water-pumping systems.

12. There are already a large number of wind-powered water-pumping systems installed in different areas throughout the country, but the wind potential in the country provides opportunities for much greater expansion.

13. It is worth mentioning that most of the wind energy systems are manufactured locally.

14. Certain criteria for site selection have been set so that concrete proposals for appropriate solar and wind technologies can be formulated and costs can be estimated. Dynamic water levels should not exceed 60 metres (m), and water consumption should total approximately 100 cubic metres (m^3) per day. Medium and high wind speed averages at the site and solar radiation data should be available, especially during the period of maximum water consumption.

15. Selection of specific sites should be based on a thorough assessment of water needs and on accessibility (for the transportation and installation of the equipment).

16. Although it is extremely difficult to meet all these criteria, it is believed that there are many sites in the country with the potential for supporting suitable solar and wind energy systems.

17. In the light of the investigations undertaken, at least 11 well sites for the installation of mechanical wind-powered pumping systems were identified in the Aleppo, Hama, Homs and Al-Quneitrah districts. The depths of wells at these sites range from 20 to 355 m, with capacity ranging from 8 to 27 cubic metres per hour (m^3/h).

18. Eight sites were also selected for PV water-pumping systems -- mainly in the Damascus, Aleppo, Al-Sweida, Homs, and Hasaka districts. The depths of wells at these sites range from 75 to 334 m, and their yield from 10 to 30 m^3/h.

19. It is recommended that four mechanical wind-powered pumping systems be installed at each site chosen; wherever the wells are too far apart, additional wells should be dug to increase pumping capacity.

20. The choice of sites for solar and wind energy systems requires reliable data on wind speed, solar radiation, location and the other elements mentioned, but it also involves the specification of appropriate technologies and cost estimates for installing the chosen system.

21. It is proposed that the technology for wind-driven pumping systems be used to modify the small mechanical systems currently produced. It is also suggested that the same type of windmill be used for the selected wells. The proposed system includes a multi-blade windmill seven metres in diameter, a piston pump and a 55-cubic-metre water storage tank. Another advantage of this system is that its output can be modified by changing the piston pump diameter and the piston stroke. Variations in piston pump dimensions are unlikely to affect the cost of the system.

22. The total cost of the proposed mechanical wind-driven pumping system would be about US$ 25,000. This includes the estimated costs for the windmill, piston pump, site preparation, transportation, water storage tank and installation.

23. The PV pumping system consists of a photovoltaic generator, an inverter, a three-phase alternating current (AC) motor-driven pump, and two water storage tanks, each with a capacity of 55 m^3.

24. The cost of the proposed PV pumping system (100 m^3/day output) for the eight wells identified by the survey ranges from US$ 34,440 to US$ 128,480, depending on the depth of wells and the facilities required.

II. THE USE OF SOLAR AND WIND ENERGY FOR BRACKISH/SEA WATER DESALINATION IN SELECTED AREAS IN JORDAN

25. The scarcity of available water resources has produced a water shortage of crisis proportions in Jordan. The problem is aggravated by increasing demand for water as a result of rapid economic and social development and the

high rate of population growth. However, the country has been considering several options for bridging the widening gap between water supply and demand; one of the most promising alternatives is the desalination of brackish and sea water.

26. There are two constraints to Jordan's use of technologies similar to those employed in other countries in the region, however. First, the process is very costly, and a country like Jordan may not be in a position to invest in large-scale water desalination facilities. The second constraint is the lack of significant conventional energy resources to provide the energy required to power these plants.

27. In the light of these factors, and considering the necessity of supplying rural and remote communities with enough water for their basic needs, the ESCWA secretariat has been involved in the formulation of projects designed to propagate the use of renewable energy sources for the desalination of brackish and sea water.

28. There are large quantities of brackish water to be found in the various basins in Jordan; totals range from 12.8 million cubic metres (mcm) in Wadi Araba to 2,700 mcm in Al-Disi. It is also believed that the quantities of brackish water in and around Al-Karnab, south Ajloun, Amman, and Al-Rajam amount to approximately 136 mcm.

29. There are a number of brackish water springs located in the Jordan Valley, the Dead Sea area, Wadi Araba, Al-Azraq and Al-Jafr; total quantities are estimated at 66 mcm, with a net potential production of 55 mcm annually.

30. It is beyond the scope of this report to elaborate on the various desalination processes; suffice it to say that distillation processes include such techniques as multistage flash evaporation, multi-effect distillation, and vapour compression, while membrane processes rely on electrodialysis and reverse osmosis.

31. Several areas in Jordan were investigated to determine the best possible sites for the installation of water desalination systems powered by renewable energy sources.

32. Aqaba gives Jordan its only access to the sea, so potential sea-water sites are limited to the shoreline of the Aqaba Gulf. Jordan's RSS has a station in this area, equipped with a desalination plant which uses a solar heating system. This station appears to be a suitable site for the installation of a hybrid (PV and wind energy) system for water desalination.

33. The potential is much greater for selecting suitable sites for the desalination of brackish water; the RSS and the Water Authority of Jordan have identified 104 wells throughout the country as strong possibilities. After studying the characteristics of these wells, the ESCWA secretariat decided that 102 of them would be suitable sites for the installation of water desalination systems powered by solar and/or wind energy.

34. A review of the various technologies used for brackish and sea water desalination indicates that electrodialysis and reverse osmosis are suitable for all applications where the salinity of the feed water is below 3,000 parts per million (ppm).

35. For higher-salinity brackish water, reverse osmosis is less expensive than electrodialysis. The reverse osmosis process has also proven reliable for sea water desalination.

36. Based on the data provided by the RSS and those compiled by the ESCWA secretariat, three sites have been selected and recommended as the most suitable for pilot projects involving the use of solar and wind energy for the desalination of brackish/sea water in Jordan.

37. Aqaba has been selected as a suitable site for installing a reverse-osmosis sea-water desalination plant driven by solar- and wind-powered systems. Sea water can be pumped to the station and the brine drained back into the Gulf. At this site, the annual average solar radiation on the horizontal surface is about 6.4 kilowatt-hours per square metre per day (kWh/m^2/day) exceeding 7 kWh/m^2 in the summer. Wind measurements indicate that the annual average wind speed at 10 metres above ground level is about 5.5 metres per second.

38. The second site chosen is Umari, where water salinity is estimated at 1,700 ppm. The site is suitable for the application of a reverse-osmosis desalination process, using a PV system as an energy source. Brackish water is available, and an RSS assessment indicates a yield of about 8 m^3/hour. As to the availability of solar energy, the annual average of solar radiation on the horizontal surface is estimated at 5.6 kWh/m^2/day. In the summer, this average exceeds 6.5 kWh/m^2/day.

39. Shomari, about 70 kilometres from Umari, is the third site recommended for the application of solar energy for brackish water desalination. The electrodialysis process is suitable for the desalination of brackish water here, using a PV system. The solar radiation at this site is similar to that of Umari, and brackish water yield measures 50 m^3/hour.

40. Various desalination system designs have been studied. The price of a hybrid unit for sea water desalination would be in the range of US$ 642,000; this includes the cost of a monitoring and measuring system.

41. For brackish water desalination, the cost of an electrodialysis unit with a capacity of 40 m^3/day is estimated at US$ 388,000, while the cost of a reverse osmosis unit with a capacity of 40 m^3/day is estimated at US$ 347,000. In both cases, the total cost includes installation and monitoring/measuring systems.

III. SOLAR ENERGY BASED HERDER SETTLEMENTS IN JORDAN

42. Jordan has herder tribes that still move across the eastern and southern parts of the country in search of water and pasture. Improving the living conditions of these tribes is part of a global strategy for the development of rural and remote areas in Jordan.

43. The RSS has been involved for more than a decade in the implementation of projects in several of these areas. Encouraged by the results of the studies carried out by the RSS, the ESCWA secretariat decided to examine the possibilities of implementing pilot projects, based on the identification of a number of suitable sites.

44. Site selection was based on various criteria: sites should be located in rural or remote areas where herder tribes are willing to live in settlements and where there are no plans for electrification in the near future; and obviously, solar radiation and groundwater should be available.

45. Taking these criteria into consideration, eight locations were identified for the installation of solar thermal and PV systems. Five well sites were also identified for the installation of PV water pumping systems.

46. The eight areas identified for solar water-heating and PV applications include Rahmeh, Al-Rishah, Beer Mathkour, Al-Greegra and Qater, in the district of Wadi Araba, and Al-Hashemia, Enaibet Al-Enaimah and Mathnat Rajil in the eastern badia (desert). The population of each of these areas ranges from 44 to 1,205. The five well sites include Tal-Hassan, Huseideh, Qattafi, Mugat and Um-Mithlu. The depths of wells at these locations range from 80 to 308 m, and the estimated output ranges from 15 to 106 m^3/hour.

47. Energy system requirements should be determined according to the socio-economic, health and educational needs of the communities concerned. The most important of these needs could be met through the provision of electricity for residential, learning, and social development facilities, for clinics (which must often refrigerate vaccines and other medicines), and for telecommunications systems. Solar water-heating units would also provide a number of benefits.

48. In order to meet the basic energy requirements at each site and provide the facilities for improving the living conditions of these communities, it is proposed that the solar energy systems to be installed include photovoltaic water-pumping systems, lighting systems for each house, solar thermal milk-condensing facilities, clinic refrigerators, and family-sized solar dryers for fodder production. All sites should be equipped with monitoring and measuring systems.

49. The cost for installing a photovoltaic water pumping and monitoring/measuring system is estimated at US$ 1,201,000. This figure covers the cost of a PV generator, power conditioning unit, submersible pump, water tank, PV support, and other requirements such as manpower, construction/installation, and a monitoring/measuring system.

50. The cost of a PV power supply system for lighting, clinic refrigeration and telecommunications facilities is estimated at US$ 341,274 for each site.

51. Estimates made at three sites indicate that the price of the solar water-heating system would be unlikely to exceed US$ 25,200. This would cover the costs of solar collectors, a storage tank and stand, pipes and other fittings, transportation, and installation.

IV. CONCLUSIONS

52. The selection of sites for the three renewable energy projects was based on technical and socio-economic studies and on the findings of field missions to the areas under consideration. A cost-benefit analysis of each site indicates that installing the suggested renewable energy systems (using available technologies) would be worthwhile.

53. It is proposed that three pilot projects be executed to: (a) demonstrate and evaluate the ability of solar thermal and PV systems to meet the energy needs of rural and remote communities, and (b) assess the performance of these systems and the potential for their replication in similar areas in the region. The proposed systems can also be used to measure and evaluate the impact of solar and wind energy technologies on the environment and on the socio-economic development of remote settlements.

54. It should also be stressed that human-resource development is vital to the success of the projects. During the course of the preliminary socio-economic survey, it became apparent that the educational levels and technical capabilities of the communities under consideration are far below the standard required for effective utilization of the proposed technologies. It is thus essential to design and conduct training programmes prior to the implementation of the projects and during the installation of the systems.

55. The final problem is one of project financing. Income is very low in the communities surveyed; most still rely on livestock (breeding and products) for their living. It is inconceivable in this case that internal sources of income could be relied upon to finance the project. Concerted efforts must be made by Governments, funding agencies and the private sector to provide the necessary support.

56. In this context, the ESCWA secretariat wishes to reiterate its previous recommendation that a regional fund for the development of new and renewable sources of energy be established.

57. These energy sources are abundant in the region, and the technologies outlined in this report are now mature enough for widespread application in many of the deprived rural and remote communities.